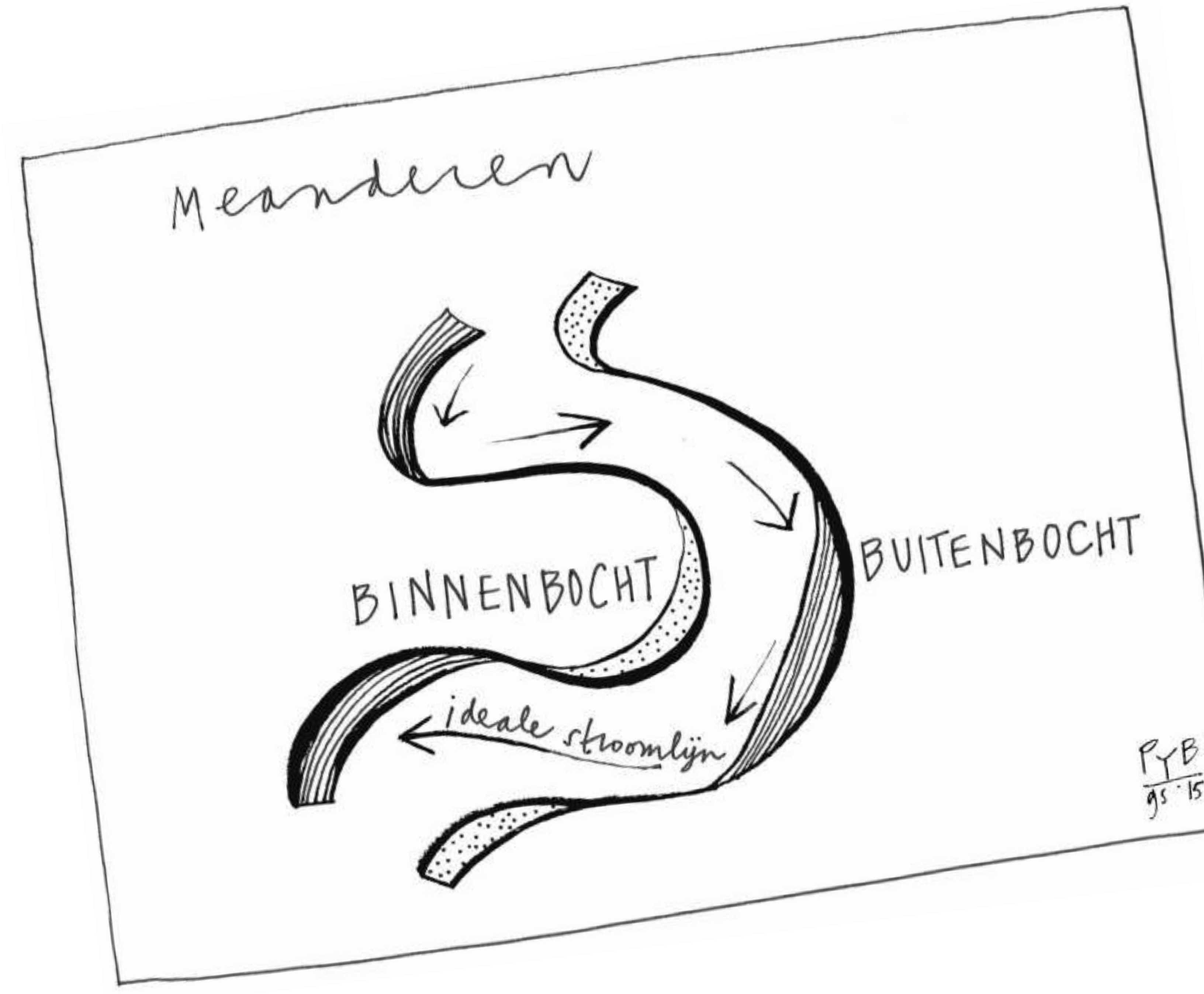
Vacancy Optional?

Valuing Vacant Real Estate from a Real Option View



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Real options are a little bit like extreme sport, people look at it and say: "Wow, that's really neat!" it's fun to watch, but when you actually sit down and try to do it yourself, it is not so easy…

Alexander Triatis
Associate Professor of Finance at the University of Maryland's Robert H. Smith School of Business

Management Summary

This graduation thesis employs real options in order to find the opportunity value hidden in real estate conversion projects. It primarily focusses on the role of the developer, financial feasibility analysis and the usage of real options in conversion of real estate. The research was conducted during an internship at Local, a project developer specialized in transformation projects. It has been conducted in partial fulfillment of the requirements for the degree Master of Science in Real Estate and Housing at the Delft University of Technology, faculty Architecture.

Introduction

How do developers knowingly take risk?

The title of the dissertation of Ellen Gehner is "*Knowingly Taking Risk"* and focusses on the elusive role of the developer. The entrepreneur who makes profits in projects which others deemed infeasible in any case. This question is also often asked in the conversion of vacant real estate to residential units. This thesis aims to provide a valuation method to value vacant offices for their potential, instead of their current state.

Problem Statement

The Netherlands has been faced with multiple years of excessive vacancy of commercial real estate. After the *IT-Hausse,* a significant part of the office stock remained empty due to a decreased demand for offices. Nevertheless, developers found ways to develop more offices under the guise of "replacement market". After significant oversupply from 2002, the economic boom in the Netherlands spurred more office developments. Due to the global economic crisis in 2008, New Ways of Working, globalization and an overall reduced demand for offices combined with the major oversupply created in the years before that, the Dutch office stock still remains for approximately 15% vacant. It is suggested that this will increase over the coming years due to hidden vacancy and a growing reduction in office demand. A majority of these office properties are also distressed, implying that the outstanding loan balance is higher than the current value (*onder water*) which puts the building owners under stress.

Transformation is an interesting alternative for a portion of the office stock. Book values are often used as a proxy for the asking price of the office in order prevent a loss. The same book values which were inflated in the years before the crisis and it could be said that offices are significantly overvalued. Project developers, faced with significant uncertainty, discount their residual value calculations in order to cope for this uncertainty. The proposed bid prices resulting from this approach, never reaches the book value. As a result, the consensus is clear: depreciation must be applied on vacant office properties, and this must happen. However, an alternative is collaboration between developers and building owners, in which both can benefit. Developers are characterized for capitalizing opportunities by actively managing their projects. They actively reduce uncertainty over the course over a development process and purposely take on risk. Risk which in many cases they cannot bear in the case of transformation projects. Traditional valuation methods provide no means to value the additional value gained over active management as uncertainty is considered a risk and is therefore reflected in the discount rate. The focus of this research is to employ a valuation method which can value the flexibility and active management developers employ and linking this to the opportunities and risks in real estate conversion, thereby answering the question: how do developers knowingly take risk?

Expected Result

The expected result of this research is to design a model which provides insight in the additional (hidden) value in real estate conversion projects. It is expected that by quantifying the risks and opportunities in real estate conversion project and by adding this additional value to traditional residual value calculations, the gap between book value and bid prices does not have to be filled by depreciation.

Research Proposal

This research aims to find the opportunity value of conversion projects and to find the optimal conditions under which a developer is willing to acquire the building and at what price. The target group of this research are the building owners and developers willing to collaborate in transformation projects. To establish the opportunity value of a real estate conversion project a combination of methods is used. The residual method is extended with the Bathtubmodel (*badkuipmodel*) which provides insight in risks and opportunities in real estate. This combination is extended with the real option valuation tools which assign value on uncertainty rather than reducing it. The complete tool, which is termed the JacuzziModel (WIP) is extended by Monte Carlo simulation techniques for optimization and analysis purposes. The input variables for the model are taken from literature but it is suggested that subjective parameters are used as conversion is project-specific. While the

focus lies on finding the opportunity value of real estate transformation projects, the corresponding aspects, such as transfer tax, VAT, financing and specific conditions for conversion will also be discussed. The main focus lies however on providing insight in the financial considerations of the conversion process and how building owner and developers can collaborate. In order to do so, a probable value of the vacant real estate must be found, therefore the main research question of this research is:

*Can **real option valuation techniques** in combination with **the Bathtubmodel** find the **value of vacant transformable real estate** under the assumption of the **limited choice** of **consolidation or immediate development?***

In which a triptych is presented in which the role of the developer is discussed and in which transformation is placed into the context of the role of developer, an elaboration on value, taxation, finance and valuation methods used in practice and their caveats and the introduction in real options. This is shaped in three (broad) sub-questions:

"What is the main role of the developer in the real estate development process?"

"How is vacant real estate valued in practice and what are the main (dis)advantages?"

"What are real options and how can they be applied in the valuation of real estate redevelopment?"

Which respectively elaborate on the task of the developer to obtain assurance and an elaboration of the development process in general, the caveats of traditional valuation methods, and the usage of real options as a strategic and a valuation tool. The research can be visualized in the following research model:

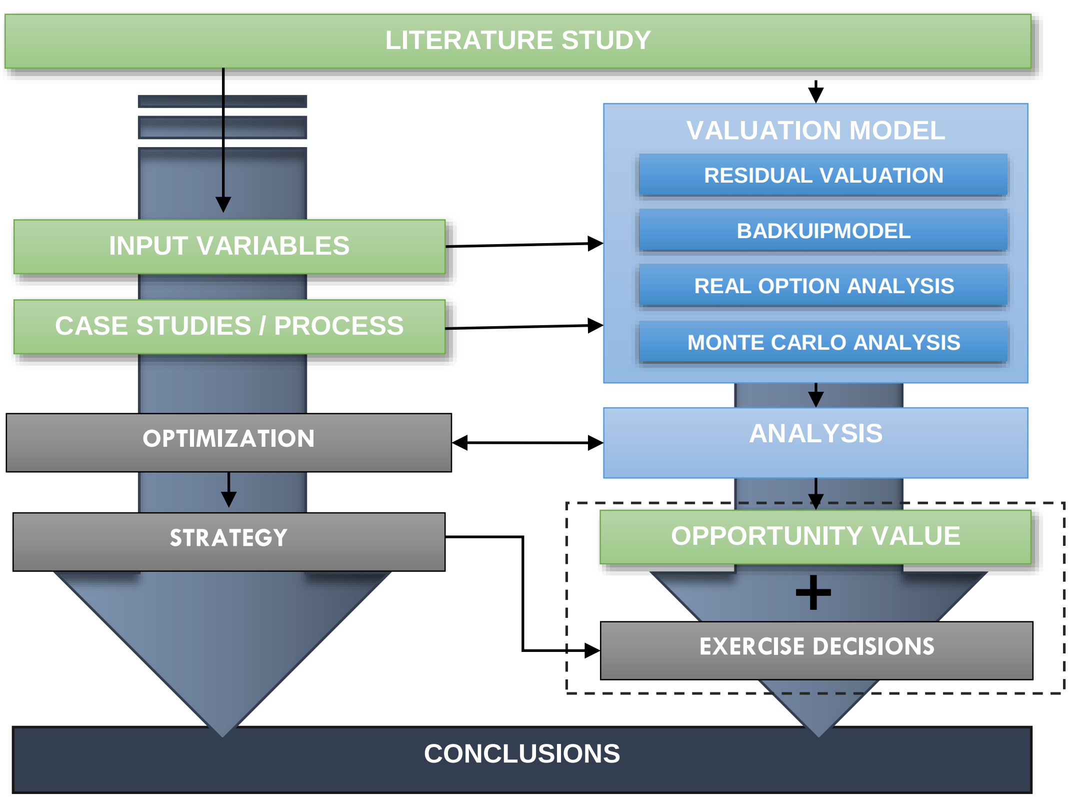


Figure 1 Research design (own illustration, 2016)

The internship at my graduating company combined with the literature research led me to a thorough understanding of the role as developer, and the development process. The model exists of two kinds of uncertainty termed uncertainty which can be controlled by the developer and market and development uncertainty, which cannot be controlled by the developer. The model is created in Microsoft Excel and the Monte Carlo plug-in Crystal Ball. The model can also be used without simulation. The model is used to examine two main development processes, the traditional development process (linear) and the upfront sale to investor process. In addition a vacant office is valued and optimization is performed in order to propose a strategy which can serve for negotiation purposes in real estate conversion between developer and building owner. The results are then analyzed and concluded.

Literature Review

The literature review in this summary will be divided in three parts, representing the three sub-questions. First, an elaboration on the role of the developer and transformation will be discussed. Second, the valuation of vacant buildings and last real options will be introduced.

Role of Developer

The role of a developer is broad. The main task of a developer is to obtain and retain assurance about six (6) main aspects of the development which span over five (5) phases as to secure a reasonable profit at project completion. In order to cope with these uncertainties the developer has several methods of approach (risk mitigation measures). The role of a developer is multi-disciplinary role encompassing design, financial, legal, technical and political aspects which are to be managed separately but influence each other throughout the process, non-linearity. Literature is mainly focused on the mitigation of risk, the opportunities which developers capitalize are of equal importance. In some situations, aspects initially perceived as opportunities can eventually become risks and vice versa. In these extreme complex and uncertain circumstances the developer attempts to make the decision whether to accept or reject a certain project, which essentially is an irreversible decision under uncertainty and manifests itself in the acquisition of land or vacant properties often paired with high investment costs. Even after thorough risk analysis has been made, risks and or opportunities (not identified in advance) which might occur after the irreversible decision has been made can alter the outcome of the project. This is well-known under academics and even more so under practitioners. The role of the developer can be summarized as follows:

> “The main role of a developer in the real estate development process is to obtain and maintain assurance about the broad range of interrelated multi-disciplinary aspects spanning over multiple phases of a project in order to justify the irreversible decision of project commitment under uncertainty which manifests itself in the acquisition of real estate, ultimately to receive a reasonable profit at project completion”.

A part of this answer is also the main focus of this research, “the irreversible decision of project commitment under uncertainty […] acquisition of real estate [vacant property]”.

The valuation of vacant properties is problematic. Not only is the valuation a function of subjective input and uncertainty of the developer, also the moment of disposal by the building owner has significant influence on the value – primarily due to reduced uncertainty which is even more so in case of transformation. This leads to the second sub-question.

Valuation of Vacant Properties

In this research the available valuation methods were examined for their applicability in the valuation of the conversion of (structurally) vacant commercial real estate. The valuation methods all have their uses, although primarily limited from a specific perspective (e.g. investor or developer) only three seem to take into account the depreciation of value and appreciation of value over time through redevelopment. These are the vacant possession valuation method, the discounted cash flow valuation and bathtub model. The vacant possession valuation method is designed to measure the influence of lease expiry dates on the current market value of the commercial property. It is limited in the sense that it is focused on the building owner and under the assumption of a currently fully let building. The discounted cash flow model approaches the valuation problem from the perspective of the prospective investor by simulating the future use and discounting it back to today in order to find the current residual value. The last model, the bathtub model is focused on the value appreciation which occurs through the development process. A limitation is the assumption that several factors are known with certainty upon which the residual value under all risk can be determined. An interesting element of this last method however is the acknowledgement of value accruement over time during the development process. It acknowledges explicitly that the future state of the development process is more valuable (assuming this is known with certainty). This is of importance for both the developer as the building owner of structurally vacant real estate. For both parties, the moment of acquisition (and respectively disposition) is of importance. The developer, as discussed in sub-question 1 benefits from additional certainty about the several uncertain aspects of development, while the building owner receives additional benefit in the form a higher disposal price. At any moment during the development process, disregarding the strategic approach, the decision-maker might wonder whether significant uncertainty has been reduced or obtaining more information is beneficial. Traditional valuation methods cannot determine the actual value of the project because they only value the current situation (which results in a residual value) and do not acknowledge mutually exclusive investments. This is the main caveat of traditional valuation methodologies as it does not take into account the future possibilities and does not assign a value to it. This implicitly also means that the actual calculation of residual value remains a black box. The second sub-question is therefore answered as follows:

“Almost all available valuation methods provide some way to value vacant real estate properly if applied correctly, they do not explicitly account for all mutually exclusive investments (such as waiting for more information), future possibilities, thereby potentially undervaluing the investment possibility.”

Or in other words, the building with an environmental permit is worth more than a building without which is the same as the value of a building with a tenant or without a tenant. The traditional methods do not provide a way to value this future possibility without explicitly doing so.

Real Options

Real options enable the appraiser or decision-maker to value the option to choose. Real options can be used as an arguably superior valuation tool or as a strategic tool. The former focusses on reactive management, enabling or acknowledging options on projects such as the option to defer a project to next year when conditions are more favorable. The latter focusses on using the option valuation framework to aid strategic decision-making, purposely implementing options in projects or to aid decision-making under uncertainty. In addition, it is acknowledged that when the project itself is an option (i.e. before the irreversible investment is made) the option holder can influence the option value to push it in-the-money (i.e. profitable project). This is the role of the developer by decreasing uncertainty, increasing potential profit and reducing potential costs (risks and opportunities). This research employs both the valuation and strategic side of real options thinking. Valuation occurs through the framework where for each individual step in the development process, the option value of the next step and the remainder of the project can be found including the latent value. Strategically in that it identifies the optimal moment to invest (i.e. acquire the building), which changes under different strategies and under different circumstances. Although no answer is given which strategy is superior to the other, the decision-maker himself should determine which strategy fits the project better. There are several ways to value real options. In prior research often the security option pricing methods were used which rely on a determination of volatility. The development process however is so specific, that subjective estimates by experts and decision-makers in form of a scenario analysis are better in terms of tractability. Therefore, the choice was made to employ the fuzzy pay-off method which enables the decision-maker to derive the option value based on only these three scenarios. This is a significant advantage to “older” option valuation methods as the composition of three scenarios is already often done in practice. The initial scenarios can be created through the bathtub model and incorporation of Monte Carlo extends this analysis.

The answer to this sub-question is as follows:

“Real options are a tool to find the opportunity value in investments under the assumption that the (future) option holder will pursue these opportunities in order to capitalize this value.’

Model

The model consists of a combination of three valuation methods which is extended by Monte Carlo analysis. It aims to find the opportunity value at each stage of two development processes. In addition, it can value vacant real estate and by optimization propose the optimal conditions when faced with an investment under uncertainty.

Residual Method

The residual method is a financial feasibility tool primarily employed by real estate developers to value vacant land or now more often vacant buildings. The valuation consists of the following formulae:

Gross Development Value – Tax – Costs – Developer Fee – Risk Premium = Residual Value

The risk premium can be a single value in form of a contingency sum or extended in separate risks and opportunities. The perceived risk can also be integrated in the parameters (e.g. gross development value).

Badkuipmodel

The Badkuipmodel is based on the residual value calculation and is a tool in which the maximum and minimum of a conversion project are calculated by deducting the residual value calculation with 6 risk categories specific for real estate conversion (asbestos, design, neighborhood and politics, environmental permit, construction and sales). These are extended in this research with pre-sale, tax and zoning plan change. The minimum is calculated by deducting the risks from the maximum. As such, a top and bottom appear. A third value is introduced, termed the adjusted building value (ABV) which is the value which increased with any transferred risks. The user can "switch on/off" the risk categories and the ABV adjusts accordingly from top to bottom. The amount of risk can be altered and the residual calculation is done on basic input variables. In this research the model is extended with the fuzzy pay-off method (FPOM) in order to find the option value of a project. In addition, the basic input variables are extended with more variables from literature and made useable for Monte Carlo analysis.

The basic input variables are split up into two categories: market uncertainties and development uncertainties. Both are assumed to be out of the control of the developer until a certain moment in the process. A market or development uncertainty is frozen by the Monte Carlo analysis if the specific risk is transferred. The specific risks are termed uncertainties under influence of developer, indicating that they can be switched to three states [1,0.5,0]. Zero indicates that the developer is responsible for the risk and the ABV is adjusted accordingly, 0.5 assumes the risk is reduced and 1 indicates that the risk is avoided or transferred from the project.

The minimal scenario, maximal scenario and ABV serve as input for the real option valuation method, the fuzzy pay-off method or in short the FPOM.

Real Option Valuation – Fuzzy Pay-Off Method

The Fuzzy Pay-Off method (FPOM) is a relatively new option valuation method (Collan et al., 2009) based on fuzzy logic. Most option valuation methods employ a form of stochastic process or variables which simulate the future distribution of the project in question. This results in a detailed distribution which, in practice, is often not adding additional value in comparison to simple scenario estimates (worst, base and best). This is emphasized in real estate, where information in general is scarce due to discretion and often information asymmetry is present (Garmaise & Moskowitz, 2004; Levitt & Syverson, 2008). This is emphasized when the building's value (physical construction) increases with the underlying value of the land (Wong et al., 2012). By employing fuzzy logic, Collan et al. (2009) the projection of uncertainty can be reduced to three scenarios (minimum, base and max) which are treated as triangular fuzzy numbers where the minimum and maximum scenario have complete non-membership and the most likely scenario has full membership. In essence, the FPOM requires only three NPV, or in this case: residual value calculations to be created to price the option (the vacant real estate). Collan (2011) defines the real option value as:

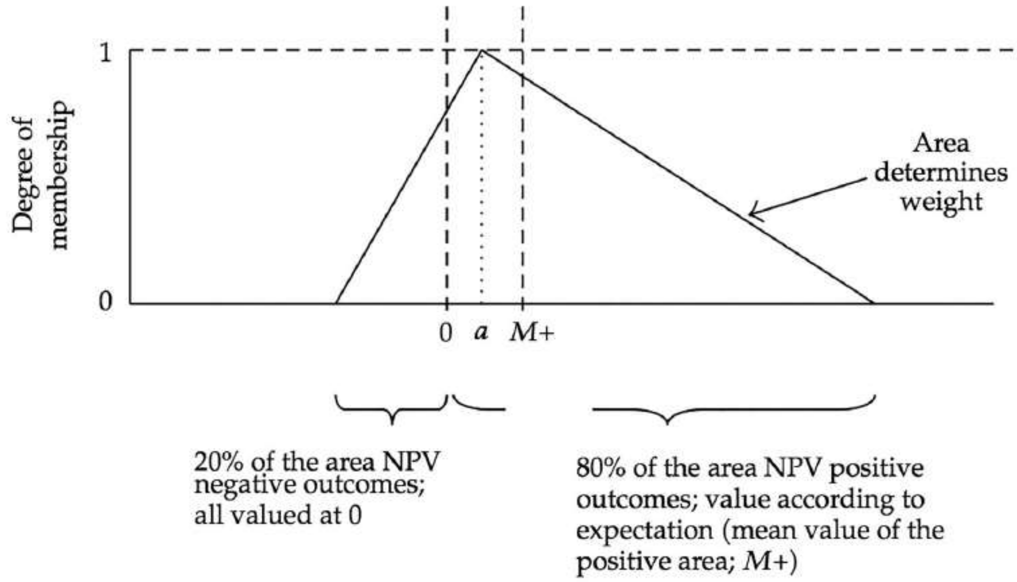
"the possibilistic mean of the positive side of the value terrain weighted by the positive area of the pay-off distribution over the whole area of the pay-off distribution"

The real option value (ROV) is then calculated as follows:

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

where $\int_0^\infty A(x)dx$ is the positive area of the pay-off distribution (triangle); $\int_\infty^\infty A(x)dx$ is the whole area of the pay-off distribution; and $E(A_+)$ is the possibilistic mean of the positive side of the pay-off distribution. The possibilistic mean can then be calculated in four ways. Note that ∝ is the distance between the best guess scenario and minimal scenario and β is the distance between the maximum scenario and base scenario.

- When the whole pay-off distribution is above zero; when $0 < (a - \propto)$, then $E(A_+) = a + ((\beta - \alpha)/6)$.
- When the pay-off distribution is partly above zero, so that zero is between the minimum and base case; when $(a - \alpha) < 0 < a$, then $E(A_+) = a + \left(\frac{(\beta - \alpha)}{6}\right) + ((\alpha - a)^3/6a^2)$.
- When the pay-off distribution is partly above zero , so that zero is equal or between the best estimate and the maximum possible; when a is below zero, but $a + \beta$ is above zero ($a < 0 < a + \beta$), then $E(A_+) = ((a + \beta)^3/6\beta^2)$
- When the whole payoff distribution is below zero, then $E(A_+)$ simply equals zero.



The FPOM can be easily employed in current risk analyses. Calculation of positive and negative side triangles can be done via simple geometry. The output of the FPOM are the option value and the success ratio (ratio between positive side and total area), which are both helpful indicators in the decision-making process.

The aim of the model is to find the optimal conditions where the option value is lower than the ABV (illustrated in Figure 2). This is achieved because the option value is a non-linear process, while the ABV is. The results are extended by Monte Carlo analysis in order to model the variables outside the control of the developer. Note that this is not a mandatory exercise.

Results

The results of the model in summary are:

- Optimal conditions can be found under limited certainty of the project and uncertainties which can serve as guidelines and the start of negotiations.
- The developer is observed to have influence on the value progression of a vacant building.
- The model acknowledges the "gut feelings" (*onderbuik*) of developers.
- By optimization a proposal strategy can be given by the model.
- The model is able to value vacant real estate on one input variable.
- The model does not account for non-linearity in the development process which can be a limitation.

Conclusion

Real options are a powerful strategic tool and should be used more often in practice if the decision-maker is able to produce three estimates of value for a min, base and max case in order to determine the potential value of a project. From the model can be concluded that yes it can value vacant properties, although more case studies are defitnely need. However, the model is more than a valuation tool for vacant properties. It can serve as an indicator for project selection and moreover strategy selection. The model is limited to 8 uncertainty parameters which can be influenced

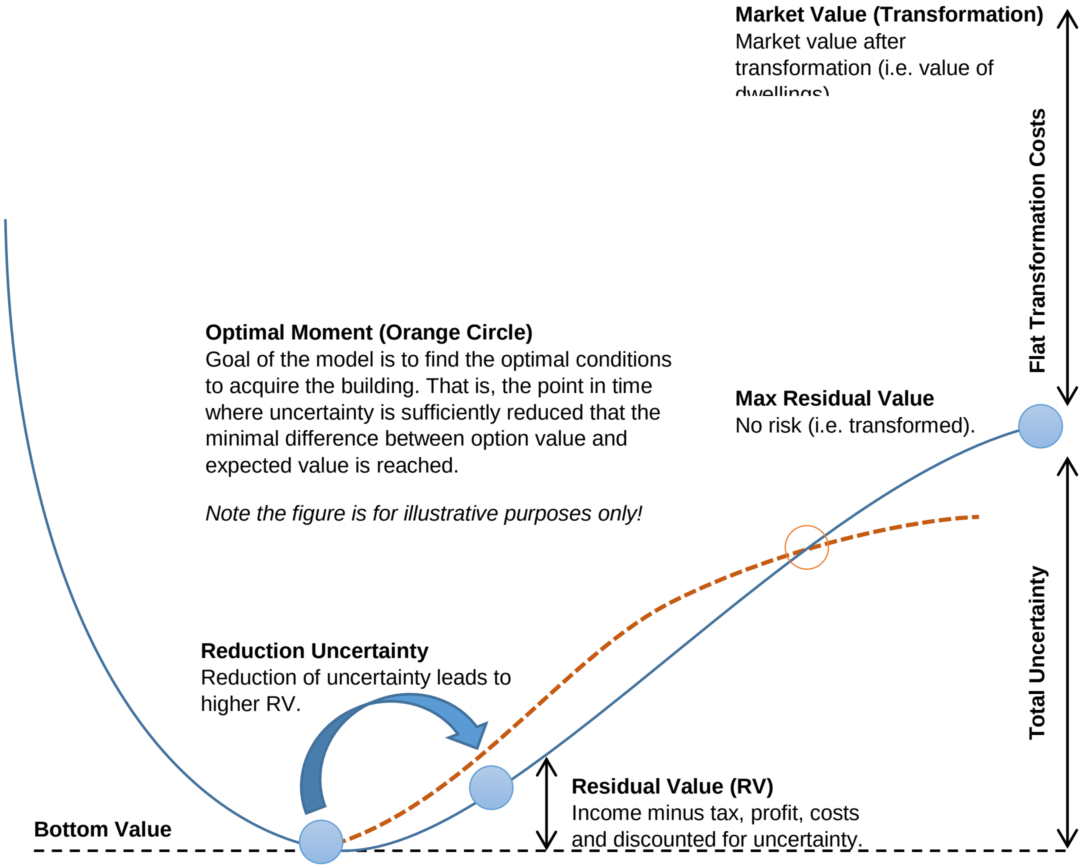


Figure 2 Illustrative explanation of the model (own illustation, 2016).

and were deemed most suitable for real estate conversion, these should be extended in more opportunities and risks within real estate.

An important notion about the usage of real options must be made. While financial options are valuable because it limits the downside risk for the owner of the option, this is not particularly true for real options. Real options find their value in acknowledging active management, and assume that the option holder acts rationally and pursues the option value. Acquiring a real option does not mean instant profit. What it does provide, is an exquisite tool for strategic decision-making and valuing flexibility which can also be employed in real estate development (valuation).

Recommendations

- **Research**
    - **Game Theory:** game theory is the research of competition and influences option values. Real estate is highly competitive, and therefore research in this direction would be beneficial for practice.
    - **Portfolio of Options:** obsolete buildings can be converted to more uses than residential alone. It is therefore a portfolio of options and should be valued as such.
- **Practice**
    - **Real Options (Thinking):** start thinking in real options implying that the focus should lie on the potential value, rather than all the risks.
    - **Collaboration:** real estate conversion is a challenge, by cooperating with stakeholders and being transparent more transformation projects can be realized, this also includes financials.

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While writing this thesis I received support and assistance from several people of which some I would like to thank explicitly.

First off, Marco d' Hulst which has created an excellent application of real options in projects, creating striking evidence for the necessity of adaptability of buildings. He has been an excellent sparring partner and provided me with feedback from time to time. He was one of the few students at Real Estate & Housing who thoroughly understands the real option terminology and its applicability within real estate.

I would like to thank Ellen Gehner, Ronald Huisman and Mikael Rühl for their input on my subject and their sophisticated view on risk analysis in real estate. During conversations it was apparent that sophisticated risk analysis is starting to integrate in real estate practice, which was about time.

During my graduation, I started an internship at Local. I would like to thank all people at Local for their input, support and kind words throughout the process. They have helped me on numerous aspects which are part of graduating and beyond. In particular, I would like to thank Arnout van Kessel and Eric Martens for the numerous discussion I had with them regarding the subject and separating and recombining theory with practice. In extraordinary particular, I would like to thank Phlip Boswinkel who not only adopted me in the Local team for an internship but also provided a start of my future career. His enthusiasm for my subject and practical guidance were much needed at that particular moment. For now, I am very much looking forward to work with the great people at Local.

Also I would like to thank Hilde and Philip, providing me with the fundamental keystones and guidance to start off what has become a longer process than they and I would have anticipated.

Obviously I would like to thank my parents in supporting my academic career. It might have taken somewhat longer than you had hoped, and your troubles half-way were sound, I managed to make it to the end.

Last I want to thank Anniek, especially for everything you did in our last weeks for graduation. Either way, I won (the bet).

Personal Motivation

My personal motivation arises from an observation I made in practice and throughout my years in the Master Track Real Estate & Housing on the Technical University of Delft. Prior to starting my master thesis and master track I was employed at Open Source Investor Services (OSIS). One of my main tasks at this young startup was maintaining and improving the residential housing index we derived from RMBS (residential mortgage backed securities) data. The goal of this index was to adjust residential valuations over time to gain insight at the current LTV (loan-to-value) and VaR (value-at-risk). To adjust these values accordingly, the OSIS team and I built several models to simulate the risk banks are exposed to in their current RMBS and CMBS (commercial equivalent of RMBS) deals.

This simulation and modelling intrigued me. Why are financial institutions so thorough in modelling and gaining insight in their risks while the actual commercial properties itself are valuated in such a heuristic, simple manner? How much is this valuation worth in a CMBS overview (which consists of 100 to 1000 properties at once) if on a building level the only compensator for risk is a simple discount rate? Of course, in the case of CMBS, sufficient diversification will hedge for all the idiosyncratic risk and the works of OSIS and banks in general will secure themselves against systematic risk, but how about direct real estate investment?

Within direct real estate investment practice is heuristic. It works – so why fix it? It is in the nature of any student to challenge the status quo and real estate is a practice in which the status quo is easily challenged yet hard to change. This thesis employs real option valuation, which intrigued me because it provided a way to value real investment opportunities. This was my personal motivation, and it will remain so. However, I have learned during my graduation internship that real estate is extremely complex, perhaps even more than the securitized products we so thoroughly analyzed.

The months during my graduation has made me respect and admire real estate even more. It is a direct product of our culture and civilization and is therefore a derivative of all people. Extreme complex, but equally interesting.

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Part I Research Overview

1 Research Proposal

1.1 Introduction

This chapter focusses on why this thesis was written and what can be expected from the results of this thesis. Section 1.2 elaborates on the perceived problem in practice, difficulties with the valuation of vacant real estate. Section 1.3 states the problem to which this thesis aims to contribute. Section 1.4 and 1.5 then introduce the main research question and the corresponding sub-questions as composed. Section 1.6**Error! Reference source not found.** lay down the proposed goals of this thesis. Section 1.7**Error! Reference source not found.** discusses the academic and practical relevance of the presented thesis. Section 1.8 presents the research model which also lays out the structure of the thesis. Section 1.9 discusses the expected results of the thesis.

1.2 Problem Analysis

In this section the perceived problem is introduced. First, the main causes of oversupply and the problem of vacancy is described following with an elaboration of the governmental need to reduce vacancy. Second, the owners of vacant commercial properties are introduced which face the problem of pending maturity of a distressed loan. Third, the discrepancy between building owner and real estate (re)developer of vacant building valuation is discussed. This is composed into a final problem statement, which this thesis aims to solve.

1.2.1 The Sharp Decline – Office Markets and Developers

The Dutch office stock is tortured with disproportionately high vacancy rates. Although take-up is rising, there is still a significant part of the total office stock vacant (15.8%) and take-up is highly concentrated (47%) in the four biggest cities of the Netherlands (DTZ, 2016). As can be seen in Figure 3 the ratio between supply and demand (black dotted line) has escalated steeply since the emergence of the credit crunch.

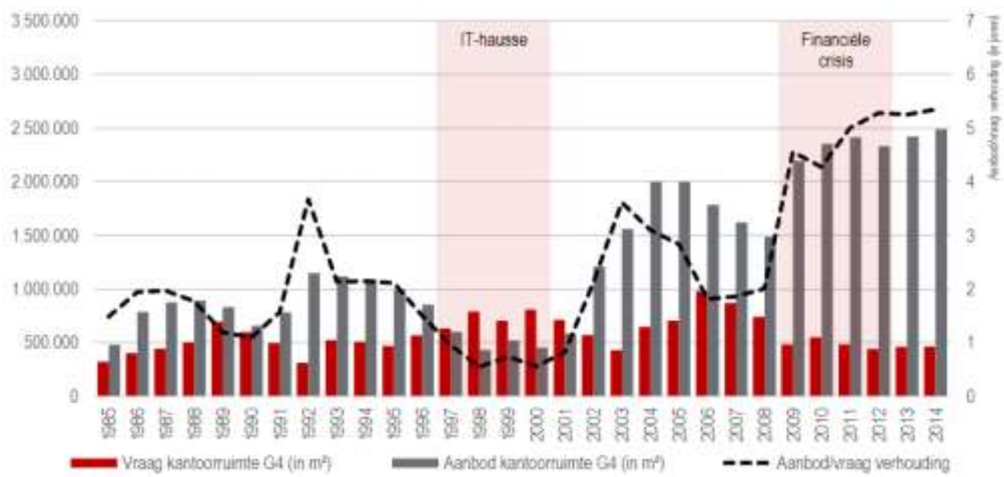


Figure 3 Supply and demand of office space in the Netherlands 1995 - 2014 (JLL, 2015).

Even before the global financial crisis emerged, there is evidence of overbuilding and significant oversupply in the years 2002 to 2006. There are two main causes to the oversupply of the office market – a reaction to the high demand in the years prior to the overbuilding (1997-2001) and the excessive use of incentives in the period thereafter (2002-2008) (Harding, 2012).

The creation of excess supply in reaction to increasing demand can be assigned to two factors. First, real estate markets are lagging markets (i.e. pork cycle, *varkenscyclus*) as described by DiPasquale and Wheaton (1996). At times of high demand, rents increase and (office) developments become feasible and highly attractive. This results in multiple developers initiating developments at the same time. Due to construction periods which often span multiple years, the supply is added later to the market at which point market conditions might have changed (i.e. demand might have diminished). Second, developers enact "irrational overbuilding", which is the phenomenon of developers to initiate developments when demand is diminishing to not miss out on any profits left in the market (Grenadier, 1996). Combined, this results in high development activity during three of four phases of the economic cycle (i.e. expansion, peak and early recession). Economic activity is more closely linked to the actual economic cycle and therefore demand and supply (of commercial real estate) are (generally) misaligned in real estate, resulting in a constant over- or undersupply.

The increased demand in economic boom times was not solved by the already available supply. In part caused by changing tenant preferences, transforming the Dutch office market to a replacement market (JLL, 2015). In addition, some developers employed questionable partnerships including excessive incentivizing leading to multiple office developments which were otherwise deemed infeasible (Harding, 2012). The usage of (excessive) incentives is outside the scope of this research but the effect will be described. The result of excessive incentives has two results: first, increased development activity which is not supported by the current economic activity and second, artificially inflated book values. The former has led to a significant oversupply of offices which are now eligible to be transformed, while the latter imposes a barrier for developers to propose a feasible business case. Building owners often use the book value as a proxy for their asking price in order to avoid a loss (H. Remøy & van der Voordt, 2014).

1.2.2 The Transformation Crusade

During the periods of excess development and after the start of the Great Recession, the government initiated multiple organizations in order to cope with the vacancy. In 2012 there were five national initiatives and organizations which aimed to reduce the high levels of vacancy and to keep transformation on the agenda: De Kantorentop, Nationaal Programma Herbestemming, H-team, Nationaal Renovatie Platform and the Expertteam Transformatie Kantoren. All, except Nationaal Renovatie Platform were organizations which were fully or partly supported by the governments (Ris, 2012). The ambition to transform offices to residential buildings was not solely based on societal reasons. The Netherlands has a significant shortage of housing, in particular for starters which want to buy and rental dwellings in the low and middle free sector. Housing becoming a feasible alternative instigated the interest in transformation and led investors to devalue their distressed properties. Transformation of vacant offices to a residential function has been the go-to solution in recent years. Approximately 1.3 million square meter of vacant office space has been transformed to a residential function (JLL, 2015). Although this is significant, it still leaves 7 million square meters of vacant office space for which there still has be found another function – transformation to residential units being the most logical, financial attractive and societal one.

1.2.3 Loss Aversion and Book Values

Owners of (structurally) vacant properties have four options: consolidation, active asset management (i.e. revitalizing the office), transformation and demolition and new-build. Selling was often not considered due to a difference between the current book value and market value. Selling the building in these cases means realizing a loss for the owner and / or shareholders of the real estate fund and is rather avoided (H. Remøy & van der Voordt, 2014), this is called “loss aversion”. Currently, book values are perceived as high and developers dictate that building owners should devalue their properties. Building owners avoid devaluing their properties for abovementioned reasons.

The existence of high book values is caused by two main reasons: the usage of inappropriate valuation methods and the unexpected accelerated economic depreciation caused by the crisis. During the holding period of a commercial property, the building should be valued annually in order to adjust the book value. McAllister et al. (2003) argues that the optimal current appraisal is a function of the weighted average of current estimated market prices, estimated from comparable properties and the previous appraised value of the property, termed appraisal smoothing. In a malfunctioning real estate market, this imposes two problems: the usage of face rents for current market prices and the usage of comparable properties. Face rents are the rents observable in the market, excluding incentives. In attracting new tenants for office developments, the usage of incentives is quite common. Incentives mask effective market rents, therefore the quoted market rent is often artificially high and incorrect. The usage of comparable properties in the valuation of vacant real estate is problematic because vacant properties are illiquid and are therefore seldom traded. As a result, the valuation of a vacant property is quite problematic and often leads to unrealistically high values.

The book value of a property can also be established by applying a yearly depreciation rate on the acquisition price. The annual depreciation costs (in a linear approach) are determined by dividing the purchase price by the financing term, this is depreciation from an accounting perspective. Economic depreciation occurs through bad market conditions. When economic depreciation does not exceed the accounting depreciation, the proposed method holds. However, when economic depreciation exceeds accounting depreciation, as occurred in the global recession, the current market value is lower than the book value. As discussed, building owners avoid selling a property below book value as it implies realizing a loss, resulting in an artificially high asking price which is a boundary for developers to acquire the building.

1.2.4 Distressed Properties

The book value problem is not problematic for a building owner if he can bear the costs of consolidation. This occurs for example when a building is part of a fund of which the majority of buildings are performing, covering the negative cash flows of the vacant property. Some building owners however, are forced to sell their building due to the maturing loan with which acquisition of the building is financed. During the economic boom of the last decade, the acquisition of properties was often financed with interest-only debt with a loan-to-value (LTV) ratio of 60-100%. Interest-only implies that only interest rate payments are monthly due for the borrower. At time of loan issue, the building was performing, meaning that the building was fully let and produced positive cash flows, covering the interest-only payments. In addition, financers and property owners believed that the building would increase in value, as is a traditional line of thought of real estate as an investment class. Thus, the exit value (the price at the building will be sold at the end of the holding period) of the building would cover for the outstanding loan balance (and in some cases also for all interest payments). During the crisis however, tenants left and no new tenants could be found, resulting in the building producing negative cash flows. Without monthly rental income, the market value of a building quickly diminishes, shifting the LTV upwards over 100%. At that point, the property is considered distressed (*onder water*). But only when the building is also appraised at a lower value, for this reason, appraisals of (structurally) vacant buildings often reflected a higher value than was realistic (for reasons mentioned above). This does not pose a problem if the building owner can find a different solution before loan maturity (e.g. refill with tenants, sell). Most structurally vacant buildings however, by definition, can or could not be filled before the loan maturity. When a loan matures, the outstanding loan balance must be repaid to the issuer (the bank) or refinancing must be arranged. Lenders are reluctant to (re)finance (structurally) vacant properties as it often entails high risk. If the outstanding loan balance cannot be repaid or the lender defaults (not meeting his monthly payments for a prolonged period of time, often more than 90 days), the ownership of the building is transferred to the lender. Banks have no interest in directly owning (vacant) real estate and therefore force the building owner to sell their building in a foreclosure sale in order to repay part of the outstanding loan balance. This is far from the most ideal solution for building owner and lender, as they both only receive a fraction of the possible value.

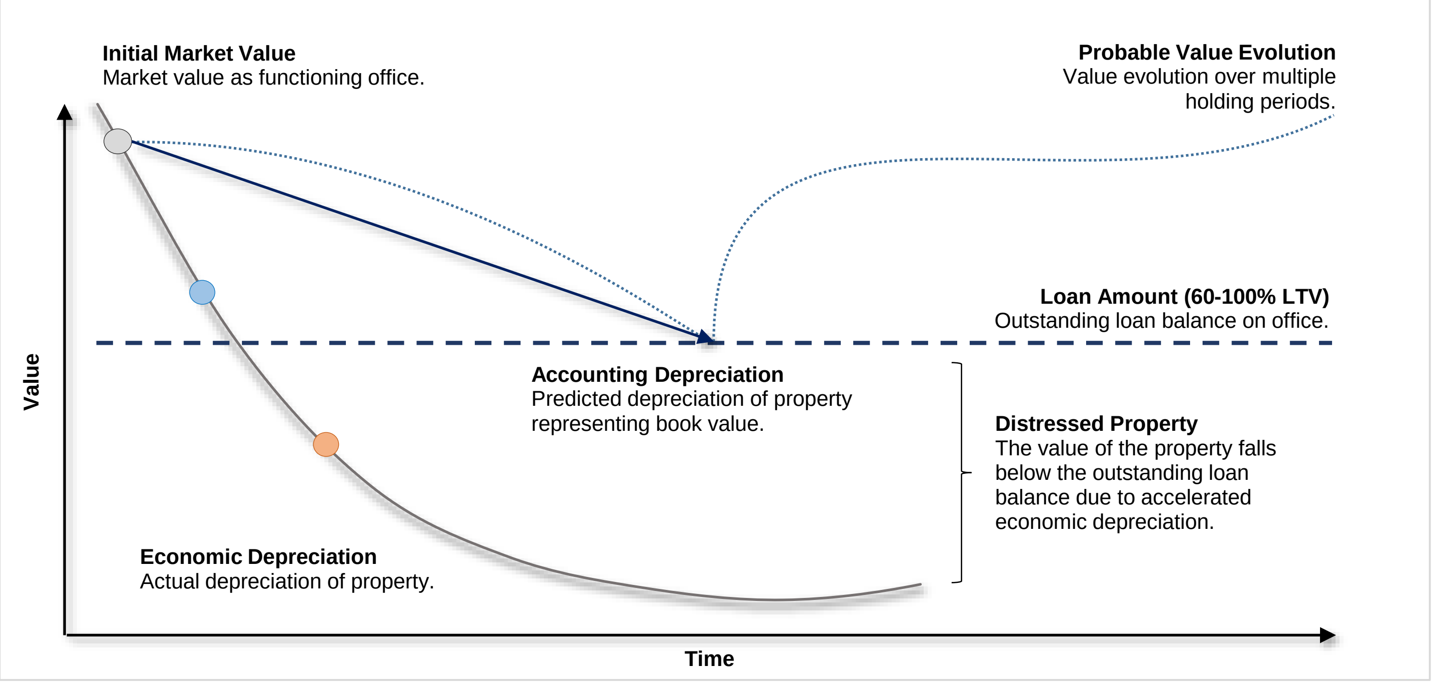


Figure 4 Value evolution of office properties (own illustration, 2016).

As can be seen in Figure 4, the predicted depreciation in a linear fashion lies below the probable value evolution. Due to the recession and a significant reduction of office demand, the actual value lies far below the predicted depreciation but above the outstanding loan amount (blue dot, vacancy due to conjuncture and recession), or distressed when structurally vacant (red dot, no future use as an office possible). Building owners rather sell their building at book value than at actual economic value but are also faced with the problem of owning a distressed property and could be forced to a foreclosure sale.

1.2.5 Value Discrepancy Developer and Building Owner

A feasible solution for building owners of (structurally) vacant real estate is transformation. Before transformation can occur, the building is (often) sold to the developer, which transforms the building, after which he sells the dwellings upfront to an investor or on the free market to consumers. As discussed, building owners rather do not sell the building below book value. Developers often employ a different valuation technique for the vacant building, namely the residual value calculation, whereas building owners often employed a discounted cash flow (DCF) approach.

The residual value calculation is composed of income minus tax, minus construction costs, additional (external) costs, financing costs and a reasonable developer's profit. In a traditional turn-key approach, the developer takes on all risk associated with the development and is therefore accounted for by applying a measure for risk, e.g. a risk premium which generally reduces (perceived) income or increases (perceived) costs. Also in other cases, where some risk will be transferred to the building owner or buying party (i.e. investor), this occurs. As a result, the residual value, often used as acquisition price (excluding transfer tax) is reduced.

The DCF approach is often used for office building owners to value their property. While using this approach, they may assume that the building is fully let now, or will be in the not-too-distant future (with or without additional investments). Alternative valuation methods (e.g. direct capitalization) may also be employed to value the building.

Adjusting the current building to its actual market value often also implies that the underlying loan becomes distressed. As a result, both the building and borrower are placed under scrutiny by the financier. In addition, devaluing the property entails realizing the implied loss (H. Remøy & van der Voordt, 2014). Both are rather avoided. Building owners believed that their properties would be re-let in the future and often have multiple properties in their portfolio covering for operational costs of some or a single vacant building, therefore they opted for consolidation and remained high book values. This was, and is no permanent solution as vacant operational costs keep accruing over time and due to maturing loans, or active strategies, the last resort for building owners is depreciation in order to allow transformation.

1.2.6 Transformation Option Value

The acquisition of vacant commercial properties as-is, where-is[1] (AIWI) entails significant risk (e.g. risk of asbestos, no zoning plan change), it is rather avoided by developers, especially for those unable to bear those risks. As a result, developers propose conditional acquisitions. An example and widely used conditional acquisition is acquisition on approval of the environmental permit (which also includes a zoning plan change). The acquisition therefore becomes optional when development activities sufficiently increase the perceived value to acquire the building. In residential property and vacant land acquisition, options are widely used. Likewise, the transformation (and acquisition) of a vacant (obsolete) building can be seen as an option on transformation much alike vacant land when the current built property can be considered obsolete (Geltner & Miller, 2011). Structural vacant commercial properties can (and should) therefore be valued as a vacant piece of land, i.e. an option to develop, in conjunction with or substituting the traditional residual valuation framework. As the property therefore becomes a real option (to develop) it can be valued by real option valuation methodologies. The application of real option valuation has been abundant in real estate development, but has (to the author's knowledge) not yet been applied to the individual value-increments during a development process.

The main difference between the application of a traditional valuation framework and threating the development as an option is how uncertainty is treated in the framework. Traditional valuation assumes that all outcomes are known with certainty, implying that the process is deterministic (i.e. it does not change over time). In reality, developers threat risk and uncertainty in a dynamic, pro- and reactive manner in which not only risks are mitigated but also room for value creation and opportunity is preserved during the development and construction process (Gehner, 2011). In traditional valuation methods, there is an assumption that all risk will occur according to their probability of occurrence. This results in a lower residual value. In reality, some risks may or may not be mitigated and hence the determination of a probability becomes problematic and subjective (Mun, 2002). When regarding the complete development process a continuous series of options (i.e. all decisions from initiation to completion) in which the developer actively aims for complete mitigation (avoidance) or minimization (reduction) of the risk, the true value of vacant real estate can be found under the influence of a developer.

1.3 Problem Statement

Traditional investment valuation methods are deterministic, assuming the development process will unfold according to the feasibility analysis. In reality, the development process can be rather seen as a continuous chain of options in which the

[1] Acquisition "as-is, where-is" is the juridical terminology for the acquisition of a property in its current state with all its current conditions, good or bad.

developer aims to pick the best solution for each option. Therefore, the process can be rather seen as this chain of options and valued as such. This can be done by real option valuation methods, but is not commonly applied in practice.

1.4 Research Question

From the above described problem analysis and subsequent problem statement the following main research question can be composed:

*How can **real option valuation techniques,** in conjunction with the **Badkuipmodel**, find the **value of vacant commercial real estate** during the development and realization process in the conversion to residential units?*

1.5 Sub-questions

In order to support answering the main research question, the following sub-questions are composed:

- What is the role of the developer in the development, realization and disposition process in the conversion of vacant commercial real estate to residential units?
- Which valuation methods are used in the valuation of vacant real estate and what are their main disadvantages?
- What are real options and how can they be employed in real estate development valuation?

1.6 Research Goals

This research has multiple goals:

- Determining the optimal exercise conditions of real estate transformation using real option valuation methods..
- Proposing and substantiate a new valuation approach for vacant (transformable) real estate.
- Determine the influence of different risk-sharing strategies on the feasibility of transformations by employing a combination of the *Badkuipmodel* and option valuation methods.

And the sub-goals:

- Determining the value of good management, or the value of the entrepreneurial character of developers by using option valuation methods.
- Exploring the applicability of real options, and the associated line of thought (real options thinking) in real estate investment and (re)development in general.
- Contribute to the quantification methods in risk analysis of real estate development.

1.7 Academic and Practical Relevance

Real option analysis and valuation has been applied to real estate in numerous ways. However, the majority of this research is applying the reactive kind of real options. This is expected since it relies on reacting optimally to market dynamics which are observable and therefore are in line with the original option valuation techniques as founded by Black and Scholes (1973). An underexposed side of real options is the proactive approach. The proactive approach entails influencing the option value while the option has already been acquired (or can be acquired). In regular (financial) options, a holder of the option is unable to influence the markets in such a way that his option will increase in value and immediate exercise (or the opposite) can be found. Real options however are applied to real projects and the holder of the option certainly has ways to increase the value of his option. This way, the option valuation techniques and its mechanics become a strategic tool, which when understood, can value the entrepreneurial ways of working developers exhibit. Moreover, when correctly understood, the developer can use the underlying mechanics and the effects of influencing them to his advantage. The use of real options tool in a proactive manner appears marginally in literature and this is where this thesis contributes in an original fashion to the existing literature. In particular combining real options with other tools to expose these strategic opportunities, without directly addressing partial differential equations is often not done in practice. Primarily because it deteriorates the scientific value of the application.

In practical perspective, the use of real options as a strategic tool can significantly contribute to the way developers approach and frame their projects. The real option framework actively encourages users to identify risks and opportunities inherent to their projects which is currently done in an obscure fashion[2]. Exposing this not only answers the question of why developers

[2] Assuming these risks and opportunities are processed in feasibility analyses but not explicitly mentioned.

are able to find subnormal profits in their projects, but also gives developers the ability to compare different projects based on their opportunity value, rather than only the residual value. Combined with the expertise of experienced developers, it unlocks the ability to be more critical in their project selection.

This research contributes academically in the following ways:

- Increase the field of knowledge regarding real option analysis in real estate development.
- By valuing the opportunity value in projects found by developers, attempting to answer the question how developers are able to be profitable under sub ideal circumstances.

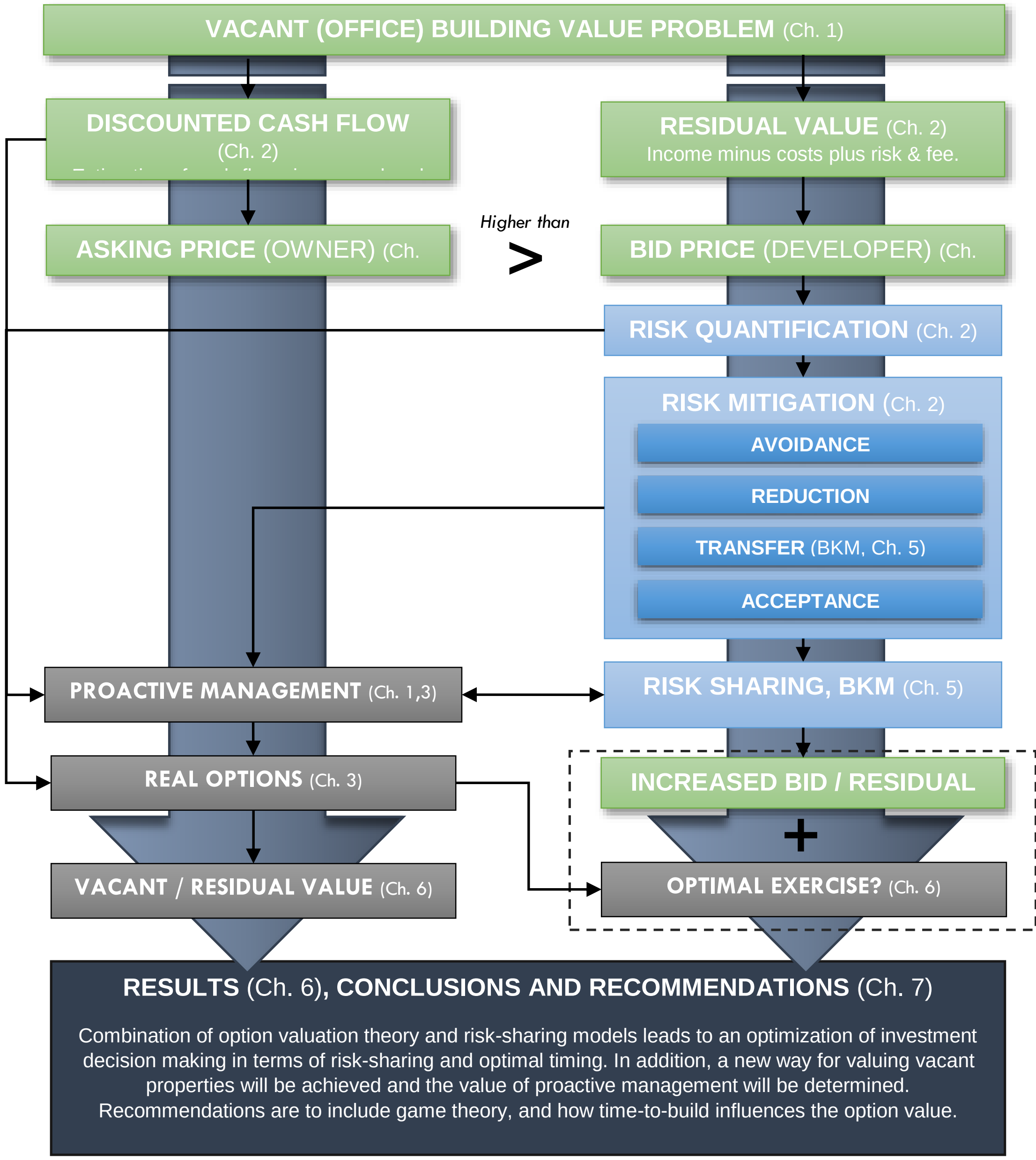
And practically in the following ways:

- Another approach to valuing vacant commercial real estate under the assumption that the building owner is limited to two choices: consolidation or redevelopment to residential properties.
- Enhance the feasibility of real estate redevelopment projects by explicitly uncovering the opportunity value found in real estate redevelopment projects.
- Providing another method to compare projects based on their opportunity value.

1.8 Research Model

The motivation for this research came from the initial presumption that option valuation could determine why building owners opted for consolidation, in favor of transformation. The main (financial) reason mentioned in literature is the difference in book value and residual value. The research model starts from this initial problem and introduces the difference between asking price and bid price (as discussed above) and why it obscures transformation. The following chapter elaborates on the used methods by building owner / investor and developer. The pitfalls of discounted cash flow are discussed, and an elaboration of the residual value calculation is given. It is argued that both valuation methods are deterministic and static but that developers proactively manage their carefully identified risks in a project by mitigation. This risk mitigation, i.e. proactive management, can be valued by real option valuation methods and the *Badkuipmodel* (BKM). Moreover, the vacant value of transformable real estate can be found under these conditions.

The former enables a user to identify the optimal exercise moment and provides a new way to value vacant office buildings, as they are similar to vacant pieces of land. The latter is designed to propose a bid price under risk-sharing agreements. Combining the two tools gives the user the possibility to identify under what risk-sharing agreements, a project is deemed sufficiently risk-free and thus can be exercised immediately, what the new bid price should be and if the project is better to be postponed into the future given the current market conditions. In addition, a vacant office building value is given by the option framework. Lastly, in the risk quantification process certain opportune values can be defined, which are translated in the option value of a project.



1.9 Expected Results

In this research the following results are expected:

- An easy way to find the real option value of vacant real estate.
- An indication of ideal circumstances for a real estate conversion project which serve as a guideline for the developer to compose a strategy or initiate negotiations.
- A quick-and-dirty analysis methodology of potential project lists of developers of real estate transformation to residential functions which focusses on financial feasibility.
- Conclusions on the use of real option valuation methods in real estate practice.

Part II Theoretical Framework

2 Transformation in Development

This chapter briefly elaborates on the motivation for transformation from a building owner perspective and the disposal moment. It then discusses the real estate development process, the phases of a development project, the inherent uncertain nature of it and the means of a developer to cope with this uncertainty.

2.1 Vacancy

When there is no demand for a specific function, the building which houses this function often becomes vacant. In these cases, transformation becomes an interesting alternative. There are four different vacancy types (Hulsman & Knoop, 1998):

1. **Initial vacancy** is vacancy occurring at the completion of a development. This can occur in all types of developments (e.g. residential, office) and accounts for 1 to 2% of the total supply.
2. **Friction vacancy** occurs through movements in the market and signals a healthy dynamic market. It is caused by tenants moving from one building to another. This can be both residential (rental and sale dwellings) and office real estate.
3. **Conjuncture vacancy** is the vacancy that occurs through the cyclical movements of the real estate market which influence the supply and demand. In low conjuncture there is a higher rate of vacancy and vice versa in high conjuncture.
4. **Structural vacancy** is the total floor space vacant for more than 3 subsequent years or those which have no future prospective tenancy (H. Remøy & van der Voordt, 2014).

Vacancy imposes a problem on building owners as it leads to deterioration of the building (and the proximity) and continuous operational costs. According to Hendriks (2016) the costs of vacancy accrue to €14 per square meter per year. Especially in the case of structural vacancy it is beneficial for building owners to look for alternative uses of their building.

2.2 Transformation

Transformation (or conversion) is not new, but has reached additional interest after the financial crisis as means to solve the abundance of commercial real estate. As a result, multiple definitions of transformation have been conceived, in this research the following, rather broad but fitting, definition of transformation is used: “transformation is a possible development when a building is structurally vacant and is assessed to be functionally obsolete, while its technical lifespan is not ended” (H. T. Remøy, 2010). The definition is fitting due to the usage of the word “possible”, referring to optionality which is the main subject of this research. The definition refers to a possible development, implying that multiple types of developments (solutions) are possible (this will be discussed in section 2.3). In this research, the focus lies on the “possible” development to residential units (i.e. conversion). Already 1 million of the reported 7 million vacant commercial real estate has been transformed, primarily to residential units (JLL, 2015), conversion is therefore not new.

2.3 Vacant Building Strategies

To cope with structural vacancy, owners have four different strategies (H. T. Remøy, 2010): consolidation, renovation, transformation and demolition and new-build.

1. **Consolidation** occurs when the building owner believes that in the future the office will be re-let or the current building value does not allow any alternative strategy to take place. The building is maintained in its current condition imposing continuous operational losses (if completely vacant). In some cases, vacancy is preferred over lower rents to escape a drastically reduced reevaluation.
2. **Renovation** is often done when future tenancy is plausible but not in its current esthetic, technical or functional state. Improving the sustainability and energy label of a building has been the most applied renovation technique in the last years. Renovation is only feasible when the future tenancy will most likely cover the investment costs.
3. **Transformation** is considered the most capital-efficient strategy of the four proposed as the majority of the building will be preserved (H. Remøy & van der Voordt, 2014). As most of the building is preserved, no new materials have to be produced and is therefore also sustainable. It is thus the most attractive option for building owners from a societal and financial point of view when the building is structurally vacant.
4. **Demolition and new-build** is beneficial when the current function has no future use in its current function (thus excluding renovation and consolidation) and the building cannot be transformed due to restrictive factors. For example, a column structure which provides no opportunity in any way to propose a different function. In some rare cases, demolition and new-build is financially more attractive than transformation, consolidation or renovation because the demand for a specific layout or type of function is so high that the costs of devaluation and demolishing costs exceed the income of the new function. In other cases, the owner of the building rather sells a vacant plot of land than the building and land together hoping he can receive a higher price that way and decides to demolish the building himself.

The abovementioned strategies are aimed at building owners, however they often do not convert the building to residential units themselves. Reasons are sectorial separation (building owners and investors do not develop and vice versa) and market separation (office investors do not invest in housing and vice versa) (H. Remøy & van der Voordt, 2014). Sectorial separation is also caused by tax authorities which state that a fiscal investment institution (*fiscale beleggingsinstelling*) is prohibited to enact entrepreneurial activities, developing real estate being one of them (Wouters, 2011).

2.3.1 Fiscal Investment Institutions

The fiscal investment institutions (*FBI*) are institutional investors which received the FBI status. The FBI status indemnifies them from paying tax on income if they adhere to a certain set of conditions. These conditions include that they do not engage in entrepreneurial activities and they disburse profits within 8 months of a fiscal year. An example of FBI status institutions are pension funds (e.g. PMT and Syntrus Achmea) but also real estate investors (e.g. Amvest and NSI). Developing real estate (i.e. the development process) is marked as an entrepreneurial activity due to the risky nature, and therefore these pension funds are not allowed to engage in these activities. An exception of this rule is when a subsidiary company (*dochteronderneming*) is established which solely (re)develops the real estate in ownership of the investor. This exception has been made in order for building owners to resolve their obsolete real estate. Activities in this subsidiary company are taxed in the same manner as a commercial developer, and therefore this exception is allowed. Whenever such a company does engage in these entrepreneurial activities before obtaining a ruling from tax authorities, all income of the going year is fully taxed in recourse. Therefore, investors holding this FBI status are reluctant to engage in such activities. Building owners and investors are however allowed to expend 30% of the WOZ-value of the property on improvements and extensions in order to continue their investment activities.

An important reason for transformation stems from the definition of transformation: “functionally obsolete”, functional obsoleteness results in not yielding any financial benefit for the building owner. Buildings which do not yield financial benefit for the building owner, and remain within its current function become (or are) unmarketable (*incourant*) (Sieverink, 2014). Unmarketable real estate is defined as: “unmarketable (obsolete) real estate relates to real property in which the current function and zoning plan does not allow alternative use and for which there is no (financial) interest in the current function” (Lorist, 2010).

2.3.2 Acquisition and Disposal

When a building owner or investor has no interest in redeveloping their property or is prohibited to do so due to their FBI status, they rather dispose their properties to a developer. Sieverink (2014) distinguishes seven moments upon which obsolete real estate can be disposed.

1. Sale “as-is, where-is” (AIWI)
2. Sale after due diligence
3. Sale after determination of program conditions
4. Sale after approved global zoning plan
5. Sale after zoning change
6. Sale after environmental permit approval
7. Sale after realization

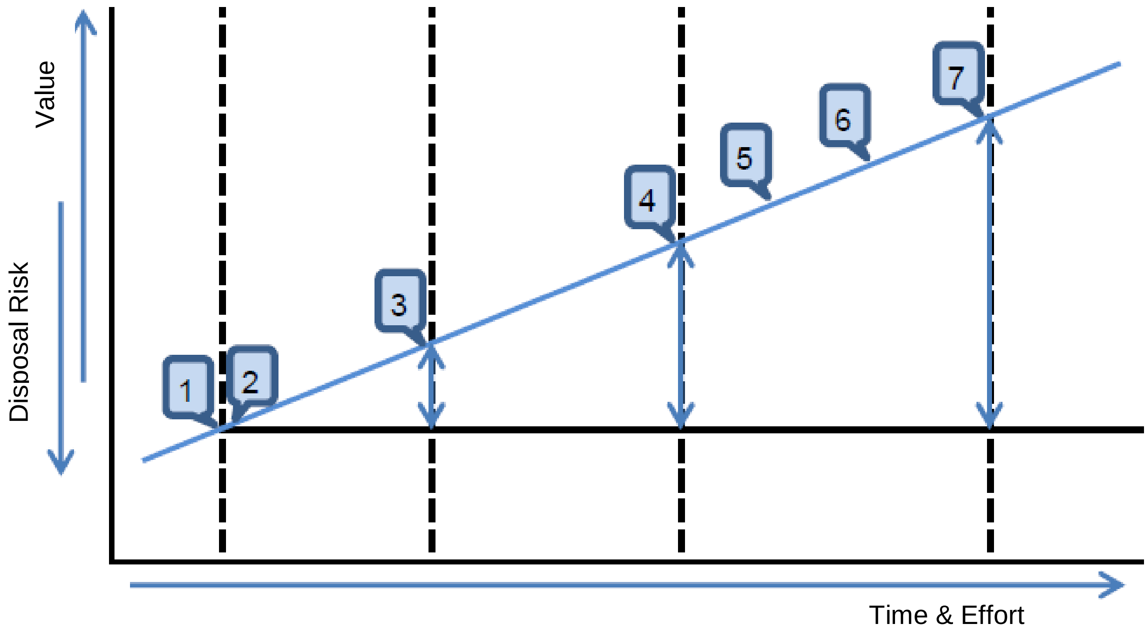


Figure 5 Disposition moments of obsolete real estate (Sieverink, 2014).

As can be seen in Figure 5, it is assumed that the value of the property increases with additional information regarding the future of the real asset. Following this rationale, Sieverink (2014) proposes an initial hypothesis that the highest value for obsolete (transformable) real estate is when the real property has been transformed. Concluding her research, she states that: “the highest and most optimal sale value for obsolete real estate which can be transformed occurs when the zoning plan change has been approved” (Sieverink, 2014, p. 36) although this is case-specific. A zoning plan change “unlocks” the potential value of a building which can be transformed.

Developers are assumed to benefit and actively pursue the lowest acquisition price. Meanwhile, they are unwilling to acquire substantial risks (i.e. obsolete real property) which might jeopardize the (potential) profit of the project. Under these conditions, they (i.e. the transforming developer) have to acquire properties in order to generate business.

2.4 Developer as Entrepreneur

The main task of a developer is to coordinate and control the development process by decreasing uncertainty and achieving project and organizational goals (Gehner, 2011). Due to the inherent uncertain nature of real estate, and real estate development in particular, the developer is often compared with an entrepreneur, knowingly taking risk (Gehner, 2008).

2.4.1 Entrepreneurship

An entrepreneur can be defined as: “persons (business owners) who seek to generate value, through the creation or expansion of economic activity, by identifying and exploiting new products, processes or markets” (Ahmad & Seymour, 2008, p. 9). Subsequently, the entrepreneur engages in entrepreneurial activities, which can be defined as: “the enterprising human action in pursuit of the generation of value, through the creation or expansion of economic activity, by identifying and exploiting new products, processes and markets” (Ahmad & Seymour, 2008, p. 9). This is extended by four key considerations:

- **Enterprising human activity;** implying that entrepreneurs are subject to the law of markets, where his profits depend on the approval of conduct by the consumer.
- **Leveraging creativity, innovation and or opportunity;** implying that an entrepreneur has to leverage existing resources (e.g. human capital, thought processes and existing markets) towards something which has additional value above that what is available.
- **Operating in a changing and uncertain environment;** entailing the risk portion of entrepreneurship, acknowledging that entrepreneurship activity takes place in an uncertain environment popularized in the PESTLN framework incorporating political, economic, socio-cultural, technological, legal and natural environments which are outside the control of the entrepreneur.
- **The creation of value;** entrepreneurs find super-normal returns which shift the market equilibrium temporarily after which imitators restore the equilibrium.

A real estate redeveloper does all of the above. For example, his products (i.e. residential units) must be accepted by consumers (or in case of office developments, office consumers) in order to secure profits. He creatively leverages existing knowledge in order to create an innovative product. His innovations are heavily subject to the PESTLN framework and ultimately he aims to create value which justifies his profits. These entrepreneurial activities acted out by developers are described in the real estate development process. It can be concluded that no debate is needed whether or not a developer can be acknowledged as an entrepreneur (Gehner, 2008; Miles et al., 2000).

2.5 Real Estate Development Process

Over the course of a development project, due to the actions of the developer, project uncertainty decreases, project influence decreases and investments accrue, see Figure 6.

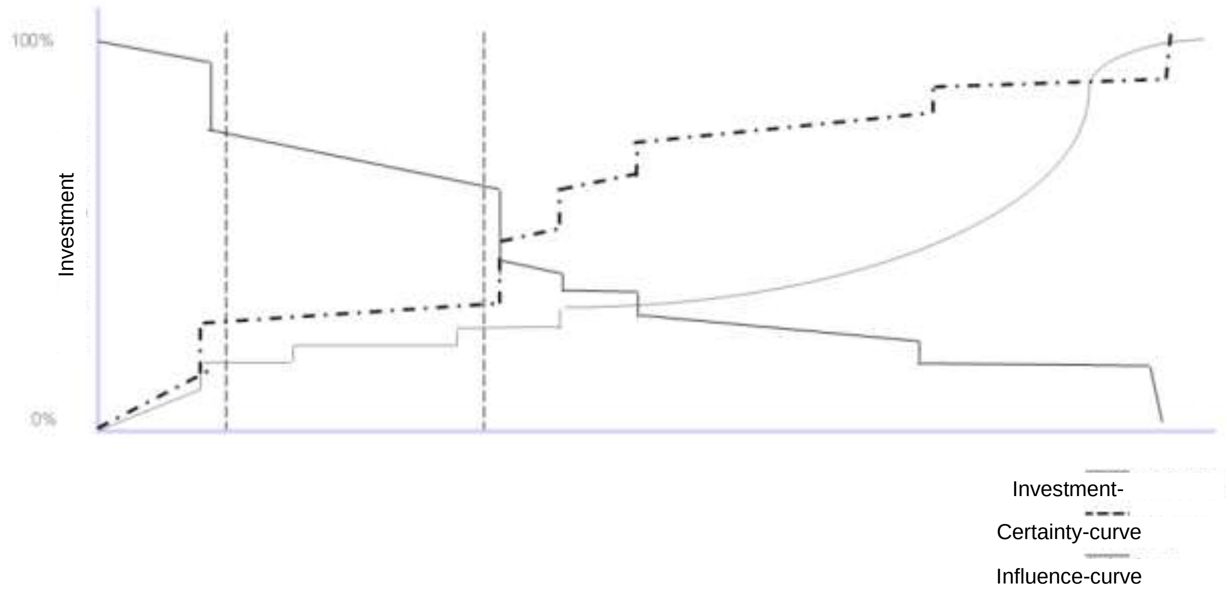


Figure 6 Investment-, certainty- and influence-curve in a (typical) development project (Gehner, 2011).

At any given moment in the process, uncertainty has been sufficiently reduced that investment can be approved (GO). If this does not occur (i.e. uncertainty remains too high), the project can be terminated (NO GO). The alternative is where multiple sources of uncertainty are identified, but suggest mitigation measures are not deemed appropriate and another solution must be proposed (GO ELSEWHERE). The investment-curve is lagging behind on the influence- and certainty-curve as at the start of the process.

From a risk management perspective, the real estate development process can be considered as the process of obtaining assurance regarding (Gehner, 2008, 2011; Ruhl, 2015):

- **Land & Building:** the spatial possibilities (e.g. building acquisition)
- **Entitlement:** the legal possibilities (e.g. acquiring environmental permit)
- **Design:** the design (i.e. spatial concept and development of an idea)
- **Financing:** the financing and financial return of the project
- **Realization:** the realization of the spatial design (i.e. construction)
- **Marketing & Sales:** the income of the project (e.g. rents and sale price)

Obtaining assurance over the 6 aspects occurs primarily in the initiative and feasibility phase which result in an investment decision (NO-GO, GO-ELSEWHERE, GO) in the commitment phase. The ability of a developer to avoid the investment if certain aspects remain too uncertain, certain risks are manifested or certain opportunities cannot be capitalized in the commitment phase implies that acquisition of the building is an option.

2.5.1 Types of Developers

Three broad categories of developers can be identified on basis of risk attitude: the fee-developer, trader-developer and investor-developer (Ritt, 2009; van Dijk, 2007). In addition, five groups of developers can be identified based on their origin (Gehner, 2008): independent developers (commercial developers), contractor-developers, asset-developers, financier-developers and "other".

1. On basis of **risk:**
    a. The **fee-developer**; the fee developer is characterized by marginal own equity and reliant on pre-financing of the future user or owner (e.g. investor). Often acts as an advisor instead of an acquisition – disposal strategy. His overall risk attitude is risk averse.

   b. The **trader-developer:** develops on own risk and generally has (some) own equity to finance projects. He acquires projects, develops them and sells them to generate profits. His risk attitude depends on the perceived risk, project scale and project complexity. His overall risk attitude can be seen as risk neutral.
   c. The **investor-developer:** the investor-developer are developers affiliated with an investor. The developer develops products which fit the investment portfolio of the investor.
2. On basis of **origin:**
   a. The **independent developer;** core business is developing projects and selling them (directly) after completion, the largest group of developers in the Netherlands.
   b. The **contractor-developer;** development activities originated from construction activities.
   c. The **asset-developer;** primarily developing assets for its own portfolio (investor-developer), this group primarily consists of commercial investors and housing corporations who are seeking for stabilized assets.
   d. **Financier-developer;** developers originated from financial institutions, have a significant advantage of large financial backing.
   e. **Others;** organizations with in-house development to develop projects for own use (or portfolio).

In this research, the independent, trader-developer is of interest, for whom real estate development is a profit-making opportunity. For these developers, the uncertainty surrounding the initial investment decision is highest.

2.5.2 Phases & Strategies

The development process consists of the complete process of acquisition (land or property), development, realization and sale and letting of the developed product. Literature agrees on the iterative nature of real estate development and its non-linearity (see section 2.5.3). Refinement occurs in the identification of phases of the development process which ranges from 8 phases (Miles et al., 2000), five (Gehner, 2011) to 3 phases (Veldhuis, 1993). Veldhuis (1993) identified the acquisition, development and sale and realization phase. In this research, the five phases identified by Gehner (2011) are used: initiative, feasibility, commitment, realization and management. The latter approach resembles reality, in particular in transformation better, because acquisition might occur in a later phase than development. In Figure 7 below is an example depicted of a transformation project.

	Initiative	Feasibility	Commitment	Realization	Management
Land & Building	Building selection	Asbestos research	Building acquisition	Stripping	
Design	Spatial concept and development of idea	Preliminary design, development of PoR	Final design and engineering		
Entitlement	Zoning plan investigation and permits	Environmental effects	Application of building permit		
Financing	"Back of envelope pro forma"	Economic feasibility analysis	Analysis of economic feasibility, arranging project financing	Controlling budget	Closing loan, generating profits
Construction		Cost engineering	Selection of contractor	Execute building contracts and supervise construction	After-care, facility / technical management
Marketing & Sales	Watch market trends and determine target market	Market analysis, feasibility study	Marketing plan, closing pre-rental and sale contracts	Marketing and promotion, closing pre-rental / sale contracts	Property management or sale of project

Figure 7 Development phases and their aspects, based on (Gehner, 2008; Ruhl, 2015).

The development process is alternated by investment decision moments (blue line), at which a developer evaluates his position and determine whether to continue (GO), alter (GO ELSEWHERE) or abandon (NO GO) the project. In particular, the commitment decision is critical as it entails full commitment and significant capital expenditures (i.e. acquisition of the land and or building). Commitment only occurs if uncertainty has been reduced significantly, as abandonment after commitment is difficult (irreversible).

In the subsections below, a short elaboration on the activities per phase are given.

2.5.2.1 Initiative Phase

Based on their experience and market knowledge developers actively search for, or monitor potential projects. Alternatively, building owners (private direct and indirect, and public[3]) might invite developers to take their building under consideration. All potential projects are placed under preliminary research to investigate their superficial potential. This is a two-step process which consists of a (1) first impression and (2) inspection (Mensing & Koppels, 2013). The first impression generally consists of analyzing the volume and shape of the property and the location. Buildings and their

[3] For example, *Biedboek.nl* is a website containing vacant properties owned by the government which are eligible for transformation.

locations are assessed for the demand and suitability of the prospective function. There are several tools available to assess the suitability of the building for transformation (e.g. Transformatiepotentiemeter, ABT-Quickscan). However, in practice these tools are seldom used and the first impression is based upon experience and done in an ad-hoc manner (Fikse, 2008). In addition, these tools lack market, financial and juridical aspects which heavily contribute to the feasibility of a project. The second step of the selection process consists of inspection, which comprises of a site (building) visit and investigation of functional, technical, cultural and juridical elements. Functional elements consist of (in most cases of transformation to residential) preference in residential areas (Mensing & Koppels, 2013) distance to facilities, public transportation, accessibility by car and parking. For residential parking, the *parkeernorm* exists. Which are regulatory minimums, specific for each area in a municipality, for parking space in the proximity of residential buildings designated for the residents. Technical elements consist of the state of the property in case of transformation such as, construction year[4], last renovation, maintenance level, construction grid and elements, the façade (e.g. operable windows) and installations. The cultural aspects of a building consist of the look and feel of the property but also includes monumental status. Monumental properties are subject to increased regulations (e.g. permitted to demolish or alter certain parts) which hinder the adaptability of the building. Juridical aspects include *het Bouwbesluit,* zoning plan, land leases and remaining tenant contracts. *Het Bouwbesluit* determines to which regulatory restrictions a building is subject and what minimum requirements it should satisfy. Those differ for office and residential buildings, and thus the needed adaptions should be possible. The zoning plan prescribes what function a property may have on a certain piece of land. In some cases, the zoning plan already allows for residential use, but more often the zoning plan has to be revised. Although municipalities are not unwilling to do so, it requires additional consideration. Land leases (*erfpacht*) are a remnant zoning tool[5] and function now primarily as an income tool mainly employed by the Amsterdam, The Hague and Utrecht municipality. The income gained (*canon*) from these leases is determined on the usage of the land and transformation can thus lead to negative financial surprises. A building which is highly suitable for transformation might still be occupied by one or multiple tenants. Before construction can be initiated, these tenants must be evicted. Because tenants are protected by *Huurdersrecht,* eviction has to be negotiated which might inflict additional costs (e.g. moving costs).

A last element, not directly applicable to any of the mentioned elements is whether the property is distressed or not (Mensing & Koppels, 2013). A building which is, or might become, structurally vacant, or a vacant building subject to refinancing in the near future[6] is also called distressed real estate. Owners of distressed real estate are often more willing to sell their building when faced with continuous negative cash flows due to operational costs and no income.

In practice, many potential projects are subject to preliminary research and shut down, while others are shut down after the (physical) inspection phase. If not shut down during the first phase, the majority of the projects are shut off in the feasibility phase when risks and possibilities are identified. Only a few project options are exercised and developed. Not only the first impression, inspection and feasibility analysis determine prosecution of a project also work capacity, developers' budget (i.e. solvability) and reputational value might influence this decision (Gehner, 2011). A summary of the initiation phase can be found below.

Initative Phase	**Activities**
Project Discovery	Project selection on experience and monitoring, and by invitation through public and private parties.
First Impression	Analysis of volume, shape and location of property. Assessing on demand and suitability of prospective function sometimes by using specific transformation tools.
Inspection	Physical inspection testing for functional, technical, cultural and juridical aspects.

Table 1 Three sub-phase process of the initiation phase (Gehner, 2008; Mensing & Koppels, 2013; Ruhl, 2015).

2.5.2.2 Feasibility Phase

The feasibility phase of a development process consists of financial calculations based on a thorough mapping of risks and possibilities which were identified during the initiation and feasibility phase. A timeline of activities considering juridical procedures, cost and revenues. Sketches of floor plans made in the initiative phase are processed to in a preliminary design by an architect. The essence of the feasibility phase is concretizing all the aspects, risks and opportunities identified in the initiative phase. The goal of this phase is to obtain assurance regarding all aspects as much as possible until a satisfactory business case is reached. Some noteworthy examples are reaching consensus with an investor and assuring all veto criteria (e.g. asbestos). However, the level of assurance is also determined by the risk attitude of the developer and can vary not only per developer, but (should) also differ with every project (Ruhl, 2015). The feasibility phase is characterized by numerous iterations and optimizations of the design and financial analysis due to new information (e.g. investors' preferences, building limitations) and reduced uncertainty.

[4] Buildings built before 1994 often contain (some) asbestos which can influence the (financial) feasibility dramatically.

[5] The land lease was formerly used for zoning and consist of leases which last up to multiple centuries and therefore still exist today.

[6] Refinancing of vacant properties is problematic as commonly no lender is willing to take on such risk. If the owner is unable to refinance the building and defaults on the current loan, the right of ownership transfers to the original lender and he (building owner) loses the building.

2.5.2.3 Commitment Phase

If a project is deemed feasible in the feasibility phase, the developer proceeds to commitment of the project. In practice this means acquisition of the building (or land), completion of the design, contracting a constructor and applying for an environmental permit. There is no specific order in these activities (e.g. a constructor can already be contracted prior to completion of the design) and often several conditions are included in contractual obligations. For example, an investor only proceeds to acquire the building if the environmental permit is granted. This has as effect that even in the commitment phase the project may be terminated if certain conditions are not fulfilled. Only if all conditions are satisfied the realization phase commences.

2.5.2.4 Realization Phase

The construction phase is quite straight-forward in construction will commence after uncertainty has been reduced (i.e. the design has been completed) and the work has been granted to a constructor. Construction remains a risky process in which several cost and time overruns are not rare. The main role of the developer in the construction phase is monitoring the process and keeping time and cost overruns to the minimum. The duration of the construction period varies per project primarily depending on the scale and complexity of the project. An advantage of transformation is that construction periods are shorter than regular projects because a major part of the construction is intact and reusable.

2.5.2.5 Management Phase

After the building has been constructed, the management phase commences. If the developer does not keep the building as an income-generating property (let out to consumers) it will be sold wholesale to an investor (who uses it as an income-generating property), or sold on the free market to consumers. In case of wholesale, a discount factor is applied. The wholesale discount is a compensation for sales (and letting) risk. The building can also be sold upfront to an investor. The discount factor is often larger as more uncertainty remains about the final rental level. The advantages of wholesale is the reduction of uncertainty about the expected sale price (or rental level). This is amplified when sold upfront. In upward moving markets, it may be more beneficial to sell the dwellings on the free market as the market value has increased over the period of the project. Another activity in the management phase (when the building is not held for income-generating purposes) is repaying the outstanding loan balances (of both construction and acquisition of the property). In most cases, the project itself is evaluated.

2.5.3 Non-Linearity & Strategies

Often, the distinction whether a project passed the initiative phase and ventured in the feasibility phase is vague. Certain aspects or activities in the initiative phase might have been resolved while others require additional investigation or management. This phenomenon is inherent to the development process and occurs almost in all phases. This is part of the interactive development process. The other part of interaction implies that certain activities in the process influence other activities or variables. In addition, certain activities are repeated (e.g. the design is optimized several times) and hence the development process is rather a non-linear, iterative process (Gehner, 2008) as opposed to what most figures indicate. This non-linearity has several implications for modelling the real estate development process, in that *the* development process cannot be modelled, but a strategy of development can be modelled (Gehner, 2008; Ruhl, 2015). Although there are no specific strategies available for a specific type of project, due to the unique character of each project, it may be that developers apply the same strategy in each project, regardless of the project itself. Ruhl (2015) argues that risk-taking strategies should be specific for each project based on the identified risks and opportunities. A different risk-taking strategy implies that certain aspects of the development have to be sufficiently certain before commitment occurs. He finds that different strategies (i.e. risk-averse, risk-neutral and risk-seeking) have different implications on risk capital and return which is in line with general theory regarding risk analysis. The sensitivity analysis shows that primarily gross initial yield and rent level per UFA are the two main contributions to the development return, closely followed by tender (i.e. building costs). Different risk-taking strategies are defined by how the developer handles risks and opportunities. For example, a risk-seeking strategy in real estate transformation is acquiring the building without conducting an asbestos research.

2.6 Risk in Development

A development project can be seen as an entrepreneurial activity where developers knowingly take risk (Gehner, 2008) by composing a risk mitigation plan for each of the identified risks. At the same time, developers attempt to capitalize on opportunities to increase the profitability of a project. In the development process the aim is to reduce the uncertainty surrounding these opportunities and risks. After identification, both opportunities and risks can be secured in a number of ways, the most obvious one being contractual obligations (e.g. determining the sale price of a project). This section describes the differences and similarities between uncertainty, volatility and risk as they are (falsely) used interchangeably in practice and how this relates to risks and opportunities. It then introduces the common risk management methods (i.e. avoidance, reduction and transfer) and the risk / opportunity categories employed in this research.

2.6.1 Uncertainty and Risk

Following the nominal work of Knight (2012), risk follows from uncertainty and should therefore not be used interchangeably. He distinguishes two types of uncertainty: one where all potential outcomes are known (or are thought be to known) in advance, and (some) knowledge of the odds of these outcomes and designates this as risk. The other uncertainty is designated genuine uncertainty. An important point Knight (2012) makes in his work is that "real opportunity only occurs in complex systems, where lots of actors interact over time", for example a real estate development project, he calls this genuine uncertainty. Genuine uncertainty, unlike risk, cannot be modelled. This is much alike the uncertainty taxonomy created by Kyläheiko et al. (2002), who distinguishes three types of uncertainty:

- **Risk;** following the definition by Knight (2012), when the probability of future events are objectively known, or at the least knowable. An important assumption herein is that events are independent from choice or actions;
- **Parametric uncertainty;** when a decision maker has certain knowledge of the structure of the problem (future, e.g. sales risk), but is uncertain with regards to the parameters (probability) of the problem. The agent facing the problem has an exhaustive list of actions he may engage in, of all the possible states of the world, and of consequences generated by his actions and the states of the world, but he has only subjective degree of beliefs with regards the probabilities of the occurrence of each state (Collan & Haahtela, 2013). Or in simpler terms, the decision maker does not know the extent of the problem but he can act upon the unknown occurrence of each state (situation) with a known outcome.
- **Structural uncertainty;** based on imperfect knowledge about the structure of future. The implications of structural uncertainty are at least the following: the set of possible relevant consequences of actions cannot be known a priori, utility functions may remain obscure, there may be unintended and unknown technological and organizational consequences of actions, and subjective probabilities of events may depend upon actions, which means these endogenized events can no longer be described as states of the world (Kyläheiko et al., 2002). In simpler terms, the decision maker does not know what is going to happen and to what extent, and if he acts upon them, the outcome of his actions is also unknown.

In regard to risk and in perspective of real estate development, Gehner (2011, p. 4) distinguishes risk and opportunity in which risk is: "a risk is a predictable and stochastic modeling definable event which leads to a negative deviation from the required return of a project". Subsequently, she defines a positive deviation as an opportunity: "an event which leads to a positive deviation […] is not covered by this [definition of risk] and will be designated as an opportunity" (Gehner, 2011, p. 4).

In real estate development, people often speak of risk, which implies that occurrence and size of future events is known or knowable, and that it is independent of choice and actions. Given that risk mitigation measures exist (see section 2.6.4) already suggest otherwise and that real estate development is rather characterized by parametric risk. That is, there is a limited knowledge regarding the size and probability of the problem and the developer only can act upon them as these problems unfold. In addition, developers are faced with genuine uncertainty as the complete development process cannot be modelled (Gehner, 2011) and it exists of multiple actors in a complex environment. Structural uncertainty might be existent in real estate development, due to the complex nature and similarities with genuine uncertainty. This does however suggest that real estate development resembles a "hit-or-miss" business, where outcomes are just a sheer matter of luck while this does not seem to be the case (Gehner, 2008).

In this research, the focus lies on risk, opportunity and parametric uncertainty. It is assumed that the decision-maker (i.e. developer) has a certain knowledge about the extent and probability of occurrence of the problem (i.e. the risks) based on experience and expertise, but it is allowed for this risk to be smaller than expected (i.e. opportunity). In addition, there is no notion about a specific action (i.e. risk mitigation measure) for each specific aspect but it is assumed that the decision-maker knows that the exhaustive list of actions which he has available will always lead to better or equal outcome than the projected risk or he will choose a different solution (i.e. an option, which will be elaborated later upon this thesis).

For example, suppose that upfront, the sales risk of a specific project is determined to be 5% of the total revenue (i.e. risk). During the development process, the developer is faced with the opportunity of selling the project upfront, but reducing the total revenue with 2% (due to discounting). However, the developer knows that the risk is not likely to occur due to favorable market conditions which became clear over time and will most likely result in a 1% loss on revenue. Without explicitly modelling this process, the best solution is taken (i.e. parametric uncertainty and implications) and reflected in the option value (see Chapter 5).

In the model, a distinction between parameters with uncertainty under influence of the developer (DVars), and uncertainty not under influence of the developer is made (MVars). These refer to respectively, endogenous and exogenous uncertainty (Bräutigam et al., 2003) . Endogenous uncertainty refers to project-uncertainty, which consists of time and project complexity (i.e. all common risks for transformation) and is assumed to be under control of the developer. The exogenous uncertainty, which primarily consists of market risks which are not under the control of the developer, or only to a lesser extent through endogenous parameters.

2.6.2 Decision Making

An important notion in the above described example is that the developer will make the best decision given the current state of the world (situation) based on his or her beliefs. This is known as decision-making. Decision-making is defined as: “the cognitive process resulting in the selection of a belief or a course of action among several alternate possibilities” (Janis & Mann, 1977) and for real estate development in particular, cognitive decision-making which is: “the decision-making process regarded as a continuous process integrated in the interaction with the environment”. Note that no specific action has to be made in decision-making, but rather the best decision is made (which might entail no action).

For real estate development, which is a complex interactive process which spans a certain, but of unknown duration, period, it can be best seen as a sequential continuous process of decision making moments where for each decision the best solution is chosen. As this research focusses on the independent developer, which has as main objective to create profit (see section 2.5.1) it can be assumed that for each decision instance, the decision which generates the most profit for the decision-maker in question (i.e. the developer) is chosen. In other words, the developer would never choose an option which would jeopardize the potential profit if he has no specific reason to do so (e.g. produce a specific product). This assumption does not hold for all developments, nor does it hold in the real world (due to the fact that it is impossible for all decision to be completely optimal), in this research however it provides a mean to justify and apply the option value found.

Before progressing prematurely, it should be noted for clarification purposes that an option is the right, but not the obligation to undertake a specific action. Which can be interpreted as the best action will always be chosen in the decision-making process because the developer has no obligation to take a sub-optimal decision.

2.6.3 Inverse Cone of Uncertainty

A real estate developer attempts to identify and mitigate risks in a development project in order to reduce the dispersion of the possible project outcomes before committing himself (GO) to the project. Commitment occurs through acquisition of the site or building. Generally, the developer focusses on maximizing the return on investment, or at least reach a minimum percentage before acquisition of the building occurs. In other words, he tries to reduce the outstanding uncertainty before committing himself to the remaining uncertainty which remains in the building. By postponing commitment, the total range of possible outcomes is reduced, this is visualized in Figure 8. The black cone represents remaining uncertainty and the blue lines represent possible value evolutions.

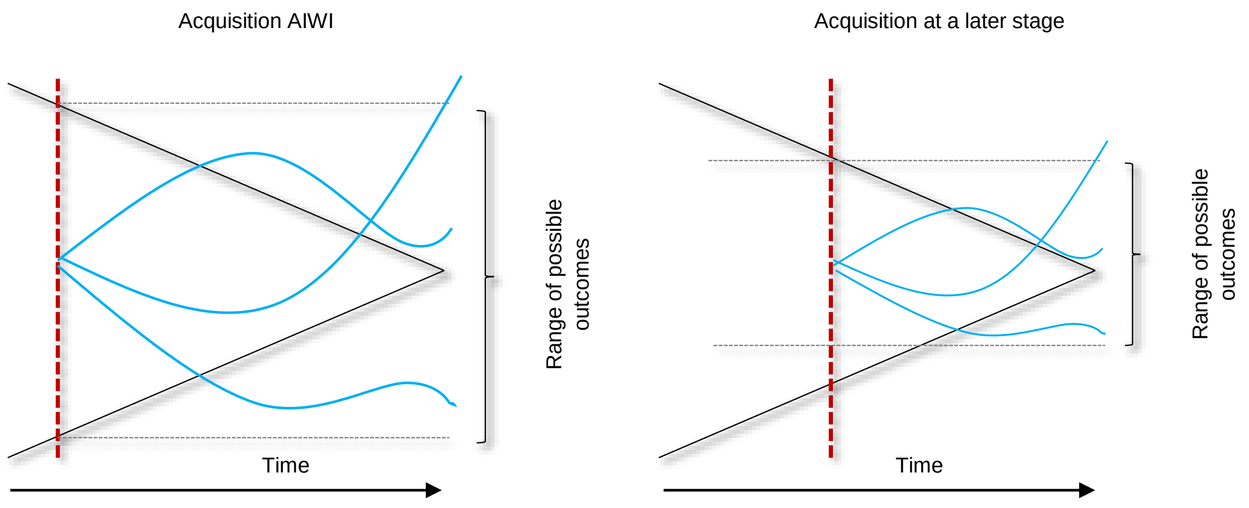


Figure 8 Different acquisition moments and possible outcomes (own illustration, 2016)

As can be seen in the figure, by reducing uncertainty the downside risk is limited more than the reduction of the upside potential. This occurs, for example, through pre-selling the project to an investor thereby securing the income at a limited discount, but reducing the total risk. If the total risk is greater than the total discount (in percentages), this phenomenon (more downside protection than upside reduction) occurs. In addition, the range of possible outcomes might be violated through unexpected events (i.e. structural and genuine uncertainty). Figure 8 is a depiction of the (inverse) cone of uncertainty.

The Cone of Uncertainty originated from chemical engineering (Bauman, 1958) and is nowadays primarily documented in software development (McConnell, 1998), in which multiple iterations of a project before completion are regular practice, but is apparent (and applicable) in all sectors and known as cost engineering. It states that estimates in the earliest phases of a project are most uncertain and can be diminished by proper risk management, specifically decision-making. At the end of the project, all risks and opportunities are resolved (i.e. all uncertainty is resolved) and the final value is known.

2.6.4 Risk Management

In response to risks (not opportunities) a developer can act in four ways, depending on his analysis of the risks regarding the magnitude of the risk and the risk attitude of the decision-maker (Gehner, 2011):

1. **Avoidance,** is the most effective measure for risk. Avoidance is excluding the chance that the risk will occur. This can be done by incorporating termination clauses to avoid obligations when certain conditions are not met. For example, investors often include a termination clause to avoid being forced to buy a project if the environmental permit is not granted.
2. **Reduction,** is useful when the developer is unable to avoid the risk. It primarily consists of reducing the chance of occurring and thus reducing the total magnitude. For example, research for asbestos can exclude the presence of asbestos or identify the extent to which the building is contaminated, including the costs to remove. Reduction of costs (and capitalization of opportunities) can for example, be fixed in contractual obligations.
3. **Transfer** of risk is best applied when a certain risk (or opportunity) is best managed by any other party than the developer. In general, the entity which is best suitable to manage the specific uncertainty should be responsible for the specific uncertainty. An example is obtaining an insurance against construction accidents.
4. **Acceptance** occurs preferably when the magnitude of risk is small, and the chance of occurring is also small. Nevertheless, it can occur that certain risks which could be mitigated, end up having to be accepted instead because the risk mitigation measures failed. Whether or not this occurs, and what measures should be taken to avoid insolvency in case it happens should be evaluated by the decision-maker.

Due to the dynamic nature of real estate development, it might, for example, occur that specific risks which were designated to be reduced upfront, are completely avoided where risks which were aimed to be avoided are only reduced. In addition, specific risks, which were not identified upfront, might arise later in the project (Sieverink, 2014). Also here, it can be acknowledged that developers are faced with a combination of parametric and genuine uncertainty. Of some specific aspects they have limited knowledge about the size and probability, while other problems might arise completely unexpected.

2.6.5 Risk Quantification

To quantify risks and opportunities the developer must assign a chance (of occurring) and effect of the specific risk (or opportunity) using suitable risk analysis methods (Gehner, 2011). This can be done in numerous ways:

- **Risk premium (RP):** the risk premium consists of adding an additional portion of capital for “unforeseen events” which are not explicitly identified or mentioned. In the process, there is no assignment of chance of occurring to the specific risks. The size of this additional portion is often a percentage of the total costs or total turnover of the project and is adjusted on the risk attitude and experience of the decision-maker. Advantages of the risk premium are ease-of-use and broad applicability. Disadvantages are the subjectivity of the method and the lack of additional information created.
- **Risk-adjusted discount rate:** the risk-adjusted discount rate (RADR)[7] is used to discount the turnover of a project (costs and revenue can be discounted at an individual rate) with a return rate (e.g. 5% for residential units) to account for the risks perceived. The RADR is composed of accruing the risk-free interest rate, a (general) risk premium of real estate and a project-specific risk component (all in percentages). The RADR discounts one period of risk (e.g. a year) and accrues over time to correct for the increased uncertainty over time and is often employed for financial feasibility analyses of longer periods (e.g. 10 years) such as the discounted cash flow (DCF). It is also employed in the gross and net initial yield (GIY/NIY) calculations (see section 3.3.2). A disadvantage of the RADR is that there is no clear way of how to determine the individual components except for the risk-free rate[8]. The RADR is thus highly subjective and especially in the last (object-specific) component. The risk attitude of the decision-maker highly influences this component without explicitly appointing the cause (e.g. location, vacancy or other risk-influencing variables). Extensions of the RADR are proposed to increase the valuation accuracy (Mirzaei, 2015) as the RADR (used in the DCF) is one of the most commonly employed methods.

[7] In practice more often referred to as simply “discount rate”.

[8] Usage of the return rate of 10-year governmental bonds is perceived as risk-free and can be employed for this component. This is done in practice, as well as in literature. This application is however debatable but outside the scope of this research.

- **Sensitivity analysis,** is a technique where certain parameters are altered by a percentage in order to observe the effect on return of the project. Often this is done by changing the parameters to a pessimistic, expected and optimistic value. By changing the parameters one by one, the individual effect of each parameter on the project return becomes clear.
- **Scenario analysis,** is an advanced version of sensitivity analysis where a combination of multiple parameters on for example, the pessimistic value is calculated. Other combinations (i.e. scenarios) are also possible which are deemed probable for the decision-maker. The scenario analysis is most useful when certain input parameters are correlated with each other (e.g. construction costs and revenue). Risk attitude does influence the composition of scenarios which increases the subjectivity incorporated in the technique.
- **Decision analysis (DA, DTA)** allows decision-makers to compare mutually exclusive project results in an uncertain environment while incorporating risk-attitude of the decision-maker as risk-effect. Usually a decision-tree is composed in order to construct this. A decision-tree consists of an initial starting point (i.e. now) and each action or time progression (event) indicates a value change. For each action or event a probability is composed. For example, sale before construction has a probability of 40% and leads to a result of X. This can be done for all actions or events in the project. As such, the decision tree can become very large and as a result cluttered and intractable. This is one of the disadvantages of the decision tree. Another disadvantage is the subjective view needed to compose probabilities of which an event will occur. In addition, events in real estate development are often linked with each other and not straight-forward where one event might lead to an altered probability in another branch of the tree. The tree then becomes dynamic which should be taken into account.
- **Expected monetary value (EMV),** is a technique where scenario analysis is combined with a probability of occurrence of the specific scenario. The EMV is therefore the summation of probability of occurrence of a scenario multiplied with the value of the scenario divided by the total number of scenarios. The result is a single value, the EMV.
- **Monte Carlo simulation** is a stochastic analysis technique named after the famous casino in Monaco. It models the project result as a distribution based upon the input parameter distributions. The user defines the probability distribution of input parameters (either subjective or on available data) and the correlation between variables (e.g. construction costs increase with sale price). The computer algorithm then draws random values from all input distributions and combines them to produce a single output. This process is repeated numerous times (i.e. iterations) resulting in a distribution of output. Additional descriptive statistics (i.e. moments of the distribution) are produced with this technique such as standard deviation, skewness and kurtosis which provide additional information about the risk and opportunity of a project. Advantages of the Monte Carlo simulation is the insight it provides through the output distribution and the additional descriptive statistics of the distribution. A disadvantage is the need to compose the input distributions.

2.6.5.1 Monte Carlo Simulation

Monte Carlo simulation is a powerful technique primarily due to the information it provides when compared to other risk analysis methods. The ease-of-use has dramatically improved by both the improved literature regarding risk analysis (in all sectors) and the introduction of plug-ins and add-ins for the Excel software package which transform regular Excel work-sheets in powerful risk analysis tools. Formerly this could be done by addressing VBA, which is the programming language of Excel, or the Data Table function of Excel. This requires the need to learn a coding language, or extensive knowledge of the Excel package. The “plug-and-play” extensions currently available are (among others) Crystal Ball and @RISK.

The Monte Carlo simulation (MCS) requires a distribution for the input parameters, thus risk is assumed. There are several statistical distributions which can be used as input and most commonly employed are the Gaussian, triangular and uniform distribution. Addressing all distributions is outside the scope of this research and therefore only the triangular distribution and log-normal distribution will be explained. The triangular distribution is convenient in use as it relies on three input parameters, the min, base and max of the specific input. This is closely related to a scenario input, in which the pessimistic, expected and optimistic value are required and is familiar to real estate investment decision-makers. The log-normal distribution is a non-negative normal distribution (bell curve) with a long tail (see Skewness).

The output distribution of a MCS can take any distribution shape and is characterized by four specific values, called moments of the distribution. The central tendencies (i.e. mean, median and mode) and dispersion (i.e. variance and standard deviation) of a distribution provide only limited information which should be extended by the skewness and kurtosis (which provide information about the symmetry of the distribution) in order to fully understand the distribution output in a risk analysis perspective.

- **Mean,** the mean is one of the central tendencies (next to median and mode) and is the average of all values in a distribution or in case of normal distributions also the expected value of the distribution. As can be seen in Figure 9 the skewness of a distribution influences the validity of using the mean as expected value. For example, if the distribution is negatively skewed, the mean is lower than the median (the value separating the higher half of a probability distribution) and the mode (the value that appears most in data). In risk analysis and optimization, the resulting distribution is often skewed and thus using the mean as expected value is invalid. The median is regarded as one of the most robust statistics because as long as not more than 50% of the data is contaminated, the value is not arbitrarily large or small. For these reasons, instead of using the mean, the median will be employed as expected value in this research.

- **Standard deviation,** the standard deviation of probability distribution is a measure of dispersion around the mean. A low standard deviation means the majority of the data is clustered around the mean and a high standard deviation means the data is spread out over a bigger range. A high standard deviation implies that the result is more uncertain. The standard deviation is also a measure for volatility (see Figure 9).
- **Skewness,** is a measure of asymmetry of a distribution (see figure 9) and implies that the expected value of a distribution is higher (negatively skewed) or lower (positively skewed) because the frequency of values are higher in those ranges. In risk analysis and in particular optimization, a negatively skewed distribution is desirable because it implies that more outcomes (the expected value) of the analysis are in the higher range. The value of skewness ranges from minus 1 to 1 [-1,1].
- **Kurtosis,** is an article of debate among statisticians. However, the common interpretation of kurtosis is the "peakedness" of the distribution which states that a higher kurtosis means slender tails of the distribution and any outliers are caused by extreme combinations of input variables and are less frequent. The reverse, a low kurtosis value, implies that the distribution is more "flat-topped" or "spread-out", indicating that the input variables combined result in more different, but less frequently per situation, situations.

The four moments of a statistical distribution provide important information. The median alone provides a single output value which can be used for a quick-and-dirty analysis, while the second and third moment (standard deviation and skewness) provide additional information about the risk perception of the output and are essential in the financial analysis of a project.

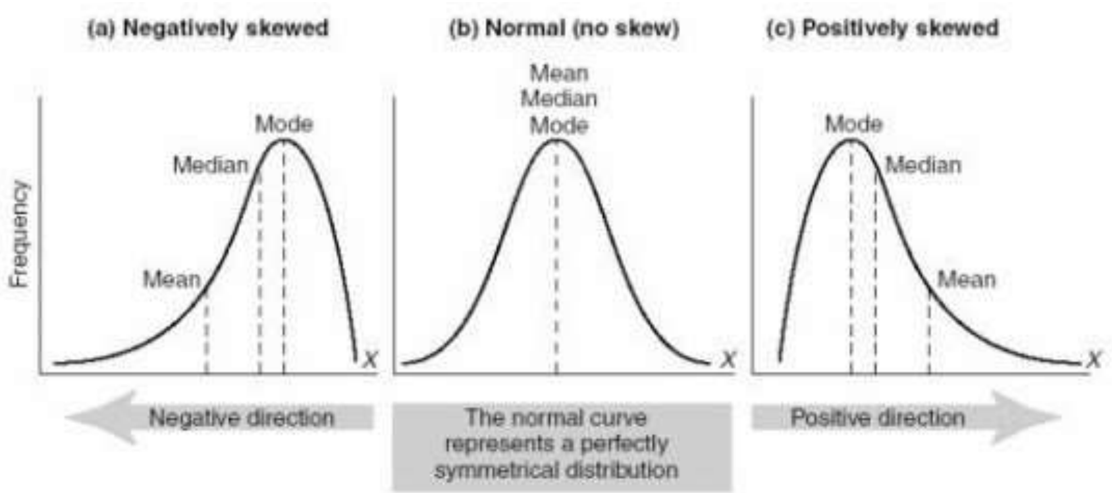


Figure 9 Skewness and central tendencies (online source, 2016)

2.7 Risk and Opportunities in Transformation

Transformation (and conversion) present several specific risks and opportunities not present in newly built development. In a cross-case analysis of 15 real estate conversions to housing, H. Remøy and van der Voordt (2014) identify 5 categories of aspects which impose opportunities and risks in the transformation process: legal, financial, technical, functional and cultural-historical (see Table 2).

#	Category	Opportunity	Risk
1	**Legal**	1. New function fits in zoning plan. 2. Conversion preferred by the neighbors. 3. Measures fit with building code requirements.	4. Zoning law: impossible to meet municipal requirements: zoning law or city policy. 5. Building code: impossible to meet requirements, e.g. regarding the noise level and fire precautions; the municipality is unwilling to cooperate. 6. Historical protection: the listed status does not allow adaptations that are required to match new user needs.

2	**Financial**	1. Low purchasing price. 2. Pre-selling implies lower financing costs. 3. Commercial activities in the plinth.	4. Developments costs: handling of procedures (loss of income, high interests). 5. Vacancy: falling incomes from exploitation or sale of the apartments. 6. Owner not willing to sell for a reasonable price due to high book value.
3	**Technical**	1. Reuse of large parts of the building (e.g. façade and construction). 2. Strong floors; possible to add extra weight. 3. Strong foundation; vertical extension possible.	4. Incorrect or incomplete building structure assessment. 5. Poor state of the main structure / foundation. 6. Insufficient shafts available. 7. Insufficient thermal and acoustic insulation in the floors and facades. 8. Insufficient daylight for housing.
4	**Functional**	1. Sufficient parking places. 2. Existing floor plan is easily adapted. 3. Extra "leftover space" not available in new developments.	4. Present grid does not fit with the measurements required for new purposes. 5. Private outdoor space is impossible.
5	**Cultural-historical**	1. Historical value, strong architectural appearance. 2. Positive impact on surrounding area.	3. Appearance of the building does not fit with the required appearance of the new function.

Table 2 Risks and opportunities in office conversion to housing (H. Remøy & van der Voordt, 2014).

Reference to the risks and opportunities are made as follows: the first legal opportunity ("new function fits in zoning plan") is referred to as L1 and the first risk of functional is referred to as Func4. All categories are referred to as following: L#, Fin#, Tech#, Func#, CuHi#.

In the following table the inclusion of the specific risks and opportunities are established. This is done in a pragmatic manner. If the developer can influence the specific uncertainty in any manner and quantify this influence in any manner, then it is included in a financial model. If not, it is omitted.

	Relevant	R/O	Description & Included in?
LEGAL	**Yes**	**L1**	Optional explicit, otherwise included in neighborhood & politics uncertainty.
	Yes	**L2**	In neighborhood & politics uncertainty.
	No	**L3**	Regarded as a veto criterion and thus omitted.
	Yes	**L4**	Inverse of L1.
	No	L5	Regarded as veto criterion and thus omitted.
	No	**L6**	Excluded.
FINANCIAL	**Yes**	**Fin1**	Objective of model.
	Yes	**Fin2**	Within sales and letting uncertainty.
	No	**Fin3**	Excluded.
	Yes	**Fin4**	Within realization uncertainty.
	Yes	**Fin5**	Sales and letting.
	Yes	**Fin6**	Objective of model.
Technical	**Yes**	**Tech1**	Within construction uncertainty.
	No	**Tech2**	Excluded.
	No	**Tech3**	Excluded.
	Yes	**Tech4**	In design uncertainty.
	Yes	**Tech5**	Included in construction uncertainty.
	Yes	**Tech6**	In design uncertainty.
	Yes	**Tech7**	In design uncertainty.
	No	**Tech8**	Excluded.
Functional	**No**	**Func1**	Excluded.
	Yes	**Func2**	In design uncertainty.
	Yes	**Func3**	In design uncertainty.
	No	**Func4**	Excluded.
	Yes	**Func5**	Excluded.
CuHi	**No**	**CuHi1**	Excluded.
	No	**CuHi2**	Excluded.
	No	**CuHi3**	Excluded.

Table 3 Selected opportunities and risks from literature (own table, based on (H. Remøy & van der Voordt, 2014))

In order to link risks and opportunities to the total uncertainty they should be quantified. Although these aspects are similar for different buildings, the direct financial consequences can differ greatly between different buildings. For each project, a specific risk premium is appointed as is common in real estate development. In addition,

2.7.1 Veto Criteria in Transformation

Specific for real estate transformation some veto criteria exist which strictly obstruct or prevent the conversion of offices to residential use. The four main veto criteria will be discussed here: the noise abatement act, air and soil constraints and external safety. The assumption is made that these veto criteria are examined and passed, prior to employing the model, except for soil quality (and in particular for transformation asbestos). Exact regulations are therefore omitted; the rules are mentioned so that developers are aware.

2.7.1.1 Noise

The noise abatement act (*Wet geluidshinder*) is the act that includes all forms of noise restrictions. This includes traffic, industry, people and construction works. The requirements in this act restrict the ability to use a location for residential use and is therefore a veto criterion. Façade noise exposure is most important. Residential use is a noise sensitive function (next to noise insensitive functions) and has a preferred limit of 48 dB and for roads and 55 dB for railways. Aldermen and the mayor can allow exemptions to the rule on a case-specific base. Possible measures are double facades and noise screens.

2.7.1.2 Air Quality

Air quality is location specific and rules are equal for all residential areas in the Netherlands. EU norms dictate that the daily concentration of particulate matter may not exceed 50 µg/m^3 for more than 35 days per year. In areas where the PM10 (particles of 10 micrometers in size) or NO_2 limits are possibly exceeded housing is not allowed under any circumstances.

2.7.1.3 Soil Quality & Asbestos

If the soil of a building is contaminated it can affect the human wellbeing and therefore has to be decontaminated. This process is very expensive and affects financial feasibility of a project significantly, therefore it is assigned as a veto criterion.

2.7.1.4 External Safety

As a rule, (re)development projects cannot take place in an area where external safety indicators were recently, or are currently exceeded. External safety indicators, or risk factors, include, but not limited to, are LPG-stations and railways or highways upon which toxic materials are transported. However it is unlikely that office buildings are situated in risk areas, and thus the transformation is not in a risk area – there are exceptions. Removing the risk from an area (e.g. displacing a LPG-station from an area redevelopment) is a costly and lengthy process and is thus a veto criterion.

The abovementioned veto criteria (with the exception of asbestos) are excluded from this research. Examining whether a location or building is violating the veto criteria is an essential part of the development process and will lead to instant termination of the project (except asbestos and land contamination). The exception of asbestos is made because most buildings which will be transformed are built before 1994. The prohibition of asbestos use was established in 1994, thus most building built or renovated before 1994 are likely to contain asbestos.

2.8 Selected Uncertainty Categories

Risks in real estate development projects lead to delay, cost overruns and an overall decrease of project return. In her dissertation, Gehner (2008) identifies seven risk categories apparent in real estate development: land development (e.g. land is contaminated), design (e.g.the design is not kept within budget), entitlement (e.g. no approval of zoning plan), financing (e.g. no financing can be arranged), construction (e.g. construction costs exceed budget), leasing (e.g. the dwellings or office is not leased on completion), sales (e.g. no investor is willing to buy). Indeed the aforementioned risk categories coincide with the risks and opportunities identified in the conversion of vacant office buildings to housing (H. Remøy & van der Voordt, 2014). In the work of Sakkers and Boswinkel (2015), based upon the work of Gehner the risk categories are altered into 6 categories and combined with the opportunities found in redevelopment which are: asbestos, product-market combination (e.g. design), neighborhood & politics, environmental permit, letting and sales. Based on the literature the following risk and opportunity categories (i.e. uncertainty categories) for real estate conversion are proposed.

#	Uncertainty Category	Description
1	**Due Diligence**	
	a. Asbestos	Asbestos is often found in buildings built before 1994, after which the use became prohibited. Most buildings eligible for transformation are constructed before this period. If found, asbestos has to be removed according to specific procedures and inflicts additional costs. In a cross-case analysis of 15 projects all projects incorporated the possible existence of asbestos (H. Remøy & van der Voordt, 2014).
2	**Design**	
	a. Design Costs	Design costs, although often defined upfront, can overrun due to several reasons (e.g. investor demands additional visualizations, market demand changes, objections or additional requests from other parties) (Gehner, 2008).

	b.	Form Factor	The form factor is influenced by the existing structure grid both positively and negatively. This also includes the need for removing or adding vertical transportation throughout the building which dampens the form factor (H. Remøy & van der Voordt, 2014). In practice, the preliminary design (primarily focusing on optimizing the floor plan) is an iterative process until fully optimized (Sakkers & Boswinkel, 2015).
3	**Neighborhood & Politics**		
	a.	Neighborhood & Politics	Approval by neighborhood and neighboring users leads to an increased financial feasibility of a conversion project (H. Remøy & van der Voordt, 2014; Sakkers & Boswinkel, 2015).
4	**Environmental Permit & Zoning**		
	a.	Environmental Permit	Initiating a conversion project before making sure the zoning plan allows housing, or the regulative authorities are willing to change the zoning plan can lead to a serious risk, possession of a vacant building with no other uses allowed (H. Remøy & van der Voordt, 2014). This is sometimes used for speculation as the value increases significantly when other uses are allowed (Gehner, 2011) and greatly increases the option value.
5	**Construction**		
	a.	Construction Costs	The specific risks inherent to construction in (real estate) development projects are documented in abundance. Due to the length of this phase and actual synthesis of all the foregoing in a physical construction it is obvious that it encompasses a broad spectrum of risks. Of importance is the notion that construction costs may overrun and thus poses a risk on the financial feasibility of a conversion project.
	b.	Additional Costs	The additional costs consist primarily of consultation costs (e.g. technical due diligence), construction fees and connection fees and is often calculated as a percentage of the construction costs. The rate depends on project complexity and scale and varies between 15 – 25% of the construction costs (Gehner, 2011; Mensing & Koppels, 2013).
	c.	Construction Time	The duration is of importance as most construction phases are financed with a construction loan. Longer construction durations imply higher financing costs which influence the financial assessment of the project.
6	**Sales**		
	a.	Sale Price	The current market state, market dynamics, investors' and consumer willingness to buy, and several other factors influence the sale price. For the developer, uncertainty regarding the sale price can be beneficial in markets which are trending up. Obtaining assurance regarding the sale price (e.g. by pre-sale to consumers or investors) can be beneficial in loan negotiations and for the organizational goals of the developer (Gehner, 2008) (e.g. remaining solvent).
8	**Tax Ruling**		
	a.	Old / New	The ruling whether the completed development is considered old or newly-build has a significant impact on the profitability..

Table 4 Uncertainty categories and aspects in real estate development (extended on basis of (Gehner, 2008; H. Remøy & van der Voordt, 2014; Ruhl, 2015; Sakkers & Boswinkel, 2015)).

The uncertainty categories presented in table 4 are based on literature research and extended by own interpretation and experience.

2.9 Conclusion

The main motivation for transformation is the expiration of the functional life of a building, after which structural vacancy develops in the building. Transformation is one of the four main strategies available for building owners, and is increasingly becoming the most interesting alternative. Due to fiscal restrictions, sectorial and market separation, buildings have to sold to developers in order to perform transformation. The developer can be seen as an entrepreneur, which also enforces and acknowledges his contribution to the real estate field. The real estate development process can be characterized as a dynamic, non-linear, iterative process in which a real estate developer aims to reduce uncertainty before committing himself to a project. By doing so it can be argued that he does not follow a pre-defined path, but is rather faced with a continuous series of decisions in which he acts rationally. It is assumed that acting rationally implies reducing costs and increasing revenue. In doing so, he will eventually reach an irreversible decision (GO) in which significant capital expenditures are made in order to commit himself to a project. Prior to this excision, several risks and opportunities can be identified, of which some are specific for transformation. In this chapter, the role of the developer was examined and it can be concluded that modelling the development process is difficult, and that modelling a development strategy can be considered useless due to the genuine uncertainty developers face. It is there, in the face of genuine uncertainty where developers find additional value which, by definition, is unable to be defined a priori.

3.1 Real Estate Markets & Cyclicality

A real estate (re)developer is an actor in real estate markets (Miles et al., 2000) and proper timing of developments in this market is of importance for the success of real estate developers and actors in general (Foo Sing, 2001; Hochberg & Muhlhofer, 2011; Mei & Liu, 1994). Real estate markets are cyclical markets and the dynamics and effects of this cyclical behavior are described and visualized by DiPasquale and Wheaton (1996). Real estate markets, in particular office markets, expose a lagging behavior, referred to as the *varkenscyclus* (translation of pork cycle) due to their lengthy construction times. As a result, an excess of demand and supply constantly alternate. In practice this means the following repeating cycle:

1. **Demand rises:** because of low rental values – demand rises for space.
2. **Rents increase:** because of an increase in demand and increasing scarcity of space.
3. **More supply:** due to an increase in rent, real estate developments become feasible and are initiated.
4. **Rents fall:** because new supply is added to the market, rental values fall and the cycle repeats.

The lagging behavior is primarily caused because supply is not added instantaneously to the market, and demand is not instantaneously solved. Real estate developments take significant time; a typical construction period can range from one to four years (or even longer). As a result, the developed supply is added later to the market. Demand for real estate is a derivative of economic activity, demographics and overall economic prosperity. Because these drivers for demand change faster than supply can be added, the market equilibrium lags behind. As a result, when one developer initiates construction, often multiple developers follow. In addition, real estate developers tend to enact irrational overbuilding, which is caused by the unwillingness to miss out on profits left in the market when demand is already declining (Grenadier, 1996), this was proved with the option theory in conjunction with game theory. This caused the oversupply in office markets in the years before the crisis (2005 – 2008) due to overbuilding in the IT-hausse and the financial crisis increased this.

Housing markets exhibit a weak form of the *varkenscyclus*. The demand for housing is primarily caused by demographic and gentrification trends which are relatively slow trends. In addition, homeowners tend to stay longer in one place than office users and most homeowners have to sell their house to someone else before leaving it (naturally, for rental dwellings this is only true to a lesser extent). The housing market is therefore relatively efficient and transparent, nevertheless housing markets exhibit the same cyclical behavior, but this is primarily caused by macroeconomic cycles and trends than the described pork cycle. That being said, the time until development completes and the supply added to the market exhibit the same behavior as the *varkenscyclus (*i.e. long construction times) and are thus of importance.

Cyclicality dramatically influences the value of a property over time, this can be seen in any real property. The same property under the assumption of no technical, esthetic and functional deterioration fluctuates over time purely due to market cycles. It can therefore be concluded, that for any real property no single value exists as can be seen in Figure 10. MV (light grey) represents the value under market conditions and technical depreciation, and MV_{MR} represents the market value on market rental rates which fluctuate over time.

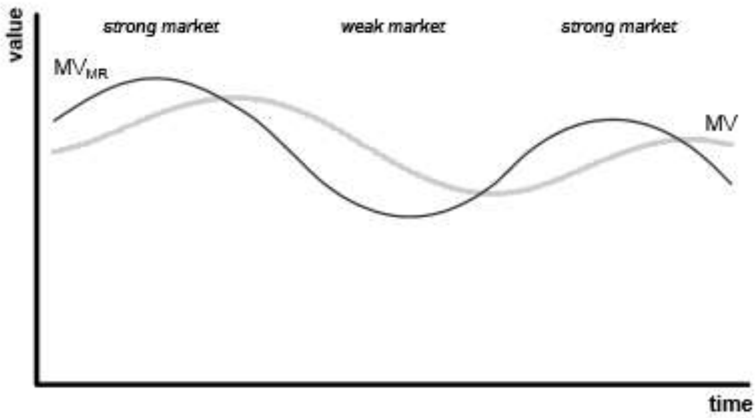


Figure 10 Fluctuating value of property in real markets (Schiltz, 2007).

3.2 Value Definition in Real Estate

Due to the high number of actors and stakeholders in real estate, multiple definitions of value are composed. Valuation is often claimed to be an art, rather than a science (Lusht, 1997) due to the numerous interrelated and uncertain parameters in valuation which are to be estimated by the appraiser. In addition, each valuation is done for a different purpose, e.g. tax, investment and acquisition purposes. As such, there are multiple definitions of value. In which case a specific value definition is used depends on the function of the valuation and stakeholders involved. Therefore, a specific building might have multiple values at the same time. These values, although all exposed to the real estate cycle, might react differently as a single property might be on multiple markets at the same time, as is the case with transformation properties (i.e. on the residential and office market at the same time).

3.2.1 Book Value

The book value is the value for which an asset is on the balance sheet of a company. There lies a distinction between owner-occupier and income-generating properties both in taxation and valuation. The book value for an owner-occupier consists of the acquisition value, minus the depreciation times the years the asset is in ownership. Several forms of depreciation are possible, of which linear is most common. In this case, depreciation may be used for tax reduction on income. For any entity who owns property for income-generating purposes (i.e. the building is let out for at least 70% to other parties than the owner) the book value is determined by market appraisal. This entails yearly reevaluation of the property. In addition, the book value for the owner may not be less than 100% of the by governmental instances determined WOZ-value (see below). Depending on how the WOZ appraisers value the building this might impose a limit on devaluation and therefore possibly hindering transformation. Devaluation of properties is generally unwanted as it entails taking a fiscal loss. However, in some cases it might be beneficial as it may reduce the tax payments due. As discussed in the problem analysis, building owners devaluated their properties in a linear fashion, or avoided devaluation completely. As a result, the majority of properties are still overvalued (i.e. high book values). This was caused by the WOZ-value limitation, but also because investors (and appraisers) were convinced that office properties would be re-let again in the future.

3.2.2 Investment Value

The investment value of an asset is the value of the asset when seen as an income-generating property (over a period of time, e.g. 10 years). This type of value is, not surprisingly, employed by investors primarily for properties which are let out (e.g. offices and residential units). Calculation of the investment value often occurs through direct capitalization methods and discounted cash flow calculation. The investment value differs from the market value as the former is aimed at a prolonged period and the market value is a single point in time, it does however occur that the investment value is used as the foundation for market value.

3.2.3 Market Value

The definition of market value is: "the estimated amount at which a property would be transferred between a willing buyer and a willing seller following proper marketing, in a business transaction on the valuation date, in which the parties were informed, prudent and would not have acted under duress" (Lusht, 1997; Wyatt, 2013). A market value is always subjective, as it can be argued to be a value determined not only under pure market parameters but could also include other value drivers, e.g. sentimental value. Due to a lack of transparency and information asymmetry in real estate markets, the market value is never a result of an efficient market. Especially in transformation projects, the market value is difficult to observe and determine due to a difference in valuation approaches.

3.2.4 WOZ Value

The WOZ value (*Waardering Onroerende Zaken*) is the value of a property as appraised for tax purposes. In some cases, individual inspection of a property is undertaken, but often valuation occurs through mass appraisal under the assumption of a comparable inspected property. It can therefore occur that nonperforming real estate is valued as if it was fully functional (i.e. fully let). Properties may only be devalued to 100% of their WOZ-value.

3.2.5 Residual Value

The residual value is often employed by developers to determine land and property values which will be developed and is often employed in valuation of vacant properties. The formula for the residual value is calculated by deducting taxes, costs, a reasonable fee and a contingency sum (i.e. risk premium) from the perceived income. The residual value determines the available capital for the acquisition of land or property.

3.2.6 Vacant Possession Value

The vacant possession value (VPV) is an addition to the current definitions of value and focusses on commercial value which will be vacant in the future. It is defined as "the market value of an [office] property, on the assumption that the property is unlet, vacant and available for occupancy (Schiltz, 2007). Schiltz (2007) argues that the value of the leases imposed on a commercial property should be adjusted for the renewal probability of the lease. As a result, which he coins the “vacant possession yield”, shifts upwards (lowering the value) as the expiry date of the current lease approaches.

3.3 Valuation Methods

This section will elaborate on the different valuation methods used in practice by building owners, investors and developers to value (commercial) real estate. For each of the described methods, the applicability of the valuation method for vacant real estate is discussed.

3.3.1 Comparable Transactions & Buildings

The comparable method comprises of selecting (at least) 3 or more comparable buildings or transactions based on location, function and other value determining factors and basing the value of the object in analysis on them (Lusht, 1997). The method is perhaps most usable for the valuation of vacant properties in comparison to the two other main tools of investors (i.e. direct capitalization method and discounted cash flow). Its usability is however limited due to the limited amount of vacant building transactions and the unique characteristics of vacant properties.

3.3.2 Direct Capitalization Methods (Gross / Net Initial Yield)

The direct capitalization method is a simple, yet useful tool to compare different properties with back-on-the-envelope calculations. It is an income-based calculation. It is primarily used in commercial real estate as it comprises of dividing the gross (GIY) or net (NIY) income of the first year by the capitalization rate, or in short cap rate. It cannot be used for the valuation of vacant properties because if the numerator, gross or net operating income, is zero or negative the value of the building is also zero or negative. Although some might argue a zero (or even negative) value is correct for structurally vacant properties, in real estate redevelopment there is always value in the land and the construction. It is therefore only true when the construction and land value is equal to the demolishing and sanitization of land costs.

3.3.3 Discounted Cash Flow

In addition to the GIY and NIY calculations, the discounted cash flow approach (DCF) is a common approach for the valuation of (commercial) properties. The two (three) methods might be used in conjunction in order to validate the results. The DCF framework consists of mapping all cash flows in the future and discounting them at an appropriate (subjective) discount rate. Summation of all discounted cash flows then leads to a net present value (NPV). The NPV serves as a decision tool. If the NPV exceeds zero, a project is deemed feasible. If multiple projects are under scrutiny, the project with the highest NPV is chosen. The NPV formula is:

$$NPV = \sum_{t=0}^{T} \frac{C_t}{(1+r)^t}$$

Where r is the appropriate discount rate (e.g. WACC).

The DCF framework, although very useful does have several limitations. First, in the DCF framework the future is supposed to be known without uncertainty (absolute certainty). It is therefore classified as a deterministic approach in which all future values are known with absolute knowledge. The weighted average cost of capital (WACC) or discount rate used to discount the cash flows, is supposed to be constant over time. Prices and returns however are dependent on changes in the discount rate and not only on variations of expected cash flows, in other words: the perception of risk may change over time and thus the discount rate should fluctuate as well. The final, and severe limitation of the DCF framework is the sensitivity of the NPV to the terminal value (Baroni et al., 2007).

In the traditional DCF approach, the terminal value is often calculated by determining an exit yield and applying this to the cash flows in the terminal year (i.e. capitalization of cash flows of terminal year). Considering the NPV is highly sensitive to the terminal value, assuming no uncertainty has significant effects. Therefore, Baroni et al. (2007) proposed a valuation method in which they divided rent and price evolutions and are governed by a geometric Brownian motion (GBM). By doing so, they allow the price evolution to vary from the rent evolution and thus free the dependence of terminal value on the rent price evolution. The phenomenon of house and rent price separation is primarily observable in tight markets (e.g. Amsterdam residential market).

Another main limitation of the DCF approach is the resulting NPV. As the decision rule states that a NPV above zero indicates a feasible investment, the decision rule becomes arbitrary when the NPV is small. In other words, can an investment opportunity with a NPV of 1 be seen as a good opportunity? This decision rule fails because absolute certainty is assumed, which is violated in all real life situations.

Using the DCF approach to value from the perspective of a building owner is intractable because the value is based upon the free cash flows (FCF). If FCF are zero or even negative (e.g. by continuous operational costs but no income) the building value is zero or even negative, similar to the direct capitalization method. If the building is valued in the future as an income-generating property (e.g. after transformation to housing) then from the resulting value the development costs, taxes and fees can be deducted to find a value for the vacant property in its current state (Mensing & Koppels, 2013).

3.3.4 Highest and Best Use (HBU)

The Highest & Best Use (HBU) method is a valuation method in which the building is valuated in its most appropriate use. For example, this could be, but is not limited to, transformation to residential use. HBU allows building owners to value their offices differently. It is argued that valuations should include a HBU (Gool & Rodermond, 2011), at least as an alternative to the traditional valuation. The HBU is rather a method of residual value calculation than a completely novel approach.

3.3.5 Residual Value Calculation

Residual value calculations are primarily used to value (undeveloped) land (Wyatt, 2013). It relies on the concept that the value of a completed development less all expenditure on land, construction and profit, must exceed the existing use value and the remainder is the value of the land or building (site value). In order to value a (vacant) building the residual value calculation is employed. The residual value calculation is a deterministic approach meaning that all parameters are assumed to be known and certain and thus reflect the inherent risk and opportunity. As a result, this leads to an opaque calculation and a single-point estimate. Project results may therefore differentiate quite significantly from the original feasibility analysis. In addition, the feasibility analysis does not provide insight regarding the risks and opportunity. When all risk is eliminated and opportunity incorporated from the calculation, the residual building value remains. Note that the residual building value differs from the residual value. The residual building value can be seen as a completed new development, whereas the residual value is the value of the existing development.

3.3.6 Vacant Possession Valuation

Schiltz (2007) proposed a method in his MSRE thesis to value partially vacant office buildings. In his thesis he argues and proposes a mathematical formula to determine the yield shift if office leases are close to expiry. From there on, he composes a vacant possession value. He validates his formula with empirical findings of 6 renounced commercial brokers. The approach of Schiltz is innovative and builds upon proven concepts such as the capitalization method. The limitation of the valuation by Schiltz is that only the yield correction of a single-tenant building can be determined. Nowadays, several buildings subject to transformation are multi-tenant or fully vacant already. The former can be relatively easily fixed by more sophisticated and extensive models. The latter case imposes the problem of having no clear market value i.e. is it possible to assume the building will be let at market value if it has been structurally vacant? Determination of the market value then becomes a rather subjective case and then the identical problems of existing methods will be introduced.

3.3.7 The Bathtub Model (*Badkuipmodel*)

The Bathtubmodel (*Badkuipmodel,* BKM) by Sakkers and Boswinkel (2015) is designed to gain insight in the value increments caused by risk mitigation measures specifically for transformation projects. In the model, three residual value calculations are performed simultaneously. The first calculation, which can be seen as the traditional valuation, discounts the resulting building value of with all 7 risk categories: asbestos and land contamination, design, neighborhood and politics, environmental permit, realization, sales and letting. For each of those risk categories, a percentage is determined by the user which either increases costs, or reduces revenue. The second residual value calculation assumes no risk (i.e. all risk resolved) and is termed the “residual building value”. Each of the 7 definable risks can be set to zero or one, indicating whether the risk has been resolved or transferred to another party. The exclusion of certain risks leads to the third residual value calculation, the “adjusted building value”. By including, or excluding certain risks, a new building value can be found. The model is primarily used to gain insight in the value progression of transformation objects and can therefore be employed as a negotiation tool.

For example, a building owner wants to transform his building into residential units but does not agree with the proposed sale price under a traditional approach. The developer is primarily concerned with the risk to which he is exposed by acquiring the building AIWI, therefore he negotiates with the building owner (or possible future investor) that if the risk occurs (e.g. asbestos is found and has to be removed) the developer will not bear this risk. As a result, the proposed building value increases. This process is visualized in **FIGURE XXX.**

The model is limited to seven risk categories but can easily be extended to incorporate numerous specific risk elements, it is therefore extremely flexible. A disadvantage of the model is the usage of a percentage of risk (i.e. risk premium) and therefore remains opaque in its current form. The BKM serves as foundation for the option valuation model which is proposed in this research.

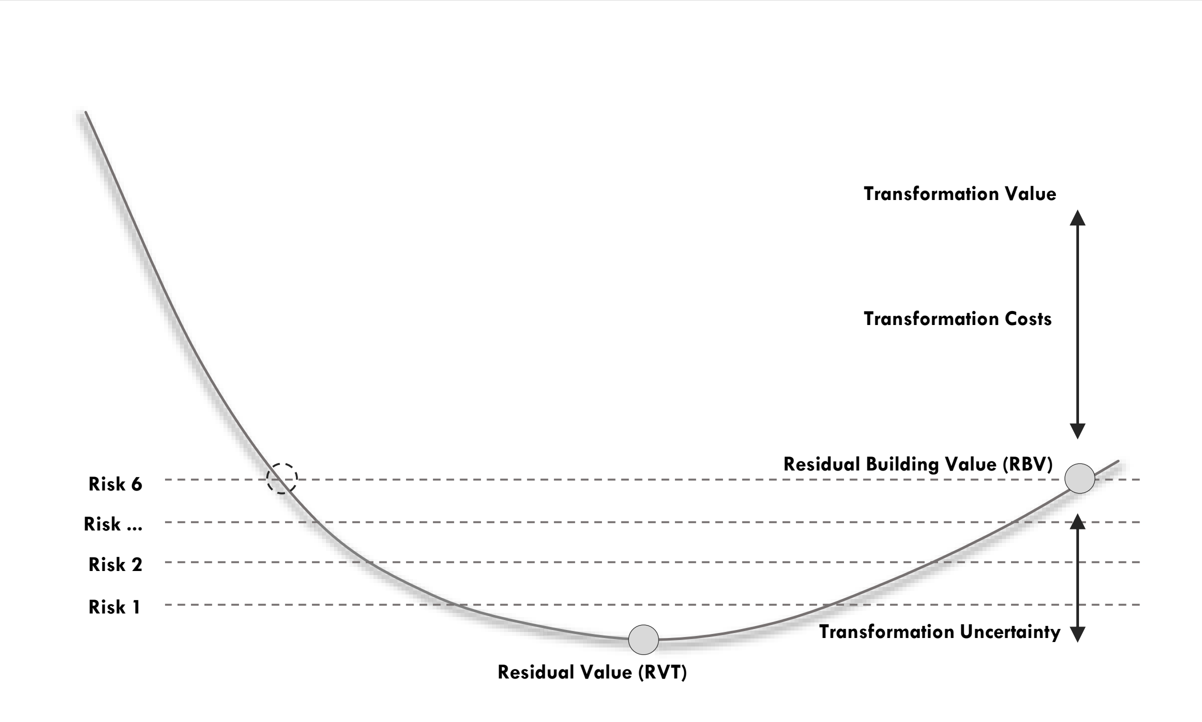


Figure 11 The Bathtubmodel and value jumps (Sakkers & Boswinkel, 2015).

In this research, the option valuation technique is applied to the BKM in order to investigate which risks should be transferred or mitigated in order to acquire the building and subsequently at what price. The increase in building value is therefore of interest.

3.3.8 Irreversible Investment Under Uncertainty

As discussed in chapter 2, the developer is faced with an irreversible investment (i.e. building or land acquisition) in an uncertain environment. A developer will only approve a project if sufficient assurance has been acquired about the individual risky aspects of a development, in order to limit the risk exposure after commitment. The amount of risk a developer is willing to take remains subjective. Most traditional valuation methods are deterministic, that is, the future is known absolute certainty and the project will unfold as described in the feasibility analysis. In addition, it therefore assumes that the developer is passive and "watches how the project unfolds" and does not change its approach as determined upfront. Ruhl (2015) finds that no strategies considering risk mitigation are apparent in literature and analyzes three approaches (risk averse, risk neutral and risk seeking) and finds that it impacts the project result. There seems to be no exact reason why no specific risk strategies are described in literature, but a possible explanation stems from the business of real estate development, in particular the development process, itself. In real estate development, it is more likely to assume that a developer actively controls the development process, rather than setting out *a priori* how to handle the development process. It can be suggested the absence of composing this detailed risk mitigation plan is caused by the genuine uncertainty a developer faces. It can be assumed that a developer acts a rational decision-maker in all phases of the development process, seeking out the most profitable or highest value-generating solution for each problem, therefore reacting dynamically to each occurring problem.

Traditional valuation methods assume passivity (Mun, 2002) or at least a specific reaction to a state of the world (e.g. decision tree analysis) and therefore assumes some certainty about the future. As argued, as the development process consists of a continuous series of options, it can be better valued as such. One important consideration to be made is the definition of magnitude within which the decision can be made. It can be assumed that this is known on basis of expert judgement and experience which are vital for developers.

3.4 Taxes in Real Estate

Real estate transaction is subject to specific taxes which vary on basis of the type of transaction and type of property. In general, when ownership of a real estate asset switches parties, either buying or selling party is obligated to pay taxes which can be either transfer tax (TT) consisting of 2 or 6 percent of the value of the property, or value-added tax (VAT) consisting of 21% of the property. Which tax is applied depends on the state of the property (old or newly-built) and has significant consequences for the profitability of a transformation project and is therefore of interest for the stakeholders.

3.4.1 Value Added Tax (VAT)

Value added tax (VAT) is charged at the delivery of a product of service and usually paid by the receiving party. In most cases, for VAT-entrepreneurs, the charged tax is deductible from tax paid on income. When a developer performs a transformation or renovation on an existing non-residential property, VAT is applied on the construction and labor costs – in some cases this is deductible.

The main regulations for VAT in (existing) real estate are:

- The supply of uncultivated land or real estate is exempt from VAT but charged with TT;
- Newly constructed real estate (until two years after completion) is charged with VAT instead of transfer tax in case of residential properties;
- When a property is bought as an investment property, the VAT is non-deductible. Letting residential units to consumers is VAT exempt, therefore paid VAT is non-deductible.

3.4.2 Transfer Tax (TT)

Transfer tax is paid by the buyer or seller (plus costs or freehold). It is based upon the economic value or purchase price of the property, whichever is highest on the moment of transaction. For non-residential buildings, a TT of 6 percent is applicable. Residential buildings are subject to a 2% transfer tax.

3.4.3 Tax in Transformation

For real estate transformation projects, specific rules may apply. In general, the rules are as follows:

- When the ownership of a newly-constructed building, or a building which is operational for less than 24 months, is transferred, 21% Vat is due to the seller of the building based upon the sale price of the building. If the new owner employs VAT applicable activities, the VAT payment of acquiring the building is deductible. Important is that renovated or transformed building can be labelled as newly-built.
- If the building has been used for at least 2 years, a transfer tax of 2 or 6% applies.
- When a property is designated as existing structure, transfer tax instead of VAT is applied.
  - The ruling whether a transformed building is existing or newly-built is vague and subjective: "if the building is perceived as new by (random) pedestrians, it is assigned newly-built". More hard factors are the extent of changes in the façade, function, severity of changes to the construction and the ratio construction costs to original value.

The rules for determining whether a building is old or newly-built are subjective, Mensing and Koppels (2013) developed, on basis of BBN Adviseurs and empirical interviews developed a set of indicators whether a transformation would be assigned newly-built or existing. If the cumulative value of the applicable indicators exceeds 55%, the transformation is likely labelled as newly-built. It should be noted that a decisive answer can only be given by a tax inspector.

Indicator	**Influence**
Façade / Exterior	
Replacement of façade	15%
Additional outdoor pace visual from street level	10%
Additional building layers	10%
Substantial annex	15%
Substantial changes to the entrance	10%
Replacement of window frames	5%
Functional Changes	
Change of functions	15%
Partial change of function or additional function	5%
Substantial change of floorplan	10%
Financial	
Ratio construction costs to original project value	5%

Table 5 Indicators of newly-built (Mensing & Koppels, 2013)

Another solution, which will not be discussed in detail as it is outside the scope of this research, is to acquire the building in a limited company, sell the shares of this limited company instead of the building itself. In this case, no consideration is made whether the building is old or new as only the shares are transferred between parties. Also transfer tax can be avoided in this construction. Considering this is a non-normal practice, it is excluded in the research. It does provide insight in how and why transformations are made feasible.

3.5 Real Estate Finance

The financial crisis has put great pressure on the availability of capital, in particular of commercial financers. Sentiment of real estate has also been negatively readjusted. Real estate overall as an asset class, is no longer the safe asset class as it used to be. The market has been recovering in the last two years, and reports show an increased interest in Dutch (commercial) real estate. The demand is clustered and primarily focused on the central business districts (CBDs) of the G4 (The Hague, Rotterdam, Amsterdam and Utrecht). This section primarily focusses on the real estate finance associated with real estate (re)development and the main issue of refinancing distressed real estate.

Real estate investments (and developments) are traditionally financed with debt, i.e. a mortgage due to the amount of capital needed. As the availability of capital decreases, building owners, investors and developers have to search for other ways of financing their ventures. In this section the traditional and innovative financing will be discussed.

3.5.1 Commercial Mortgages

The commercial mortgage (CM) is the most traditional form of financing commercial real estate. Loan terms are undefined and are established under negotiation and typically vary between 3 to as long as 25 years, depending on the perceived risk of the collateral (the underlying property). An important part of a loan is the loan-to-value (LTV) ratio. The LTV stands for the amount of the loan compared to the value of the property. The important aspect of commercial mortgages is the interest payments and amortization (repaying the loan amount) of the loan, called the debt service. There are three general types of mortgages: annuity, linear and interest-only. An annuity loan is a mortgage with constant interest and amortization payments by the borrower. A linear mortgage is a loan with constant amortization decreasing the interest due. An interest-only mortgage entails no amortization payments but only interest payments and repayment of the total loan amount at maturity of the loan. The financed asset serves as a collateral for the loan.

3.5.2 Construction Mortgage

Construction mortgages are used to finance the construction period of a development, the loan terms therefore vary between 1-3 years and are typically based on the planning of the developer. Cash is disbursed gradually over the course of the project and is often linked to milestones in the project (e.g. creation of foundation). Construction mortgages have no amortization, and thus the complete loan amount is repaid by the borrower at the end of the construction. If the borrower is unable to do so, high interest rates apply on the outstanding debt. It is therefore of importance to avoid any time overruns in the project.

3.5.3 Sale and Leaseback Construction

Sale and leaseback (S&L) is not only used in corporate real estate, but also to finance transformation projects. With the S&L construction the building owner sells the land on which the building is constructed to the municipality and leases it back from the municipality. The received capital from the sale is used to finance the transformation. Caveats of this construction is the determination of the land value and the foregone profits due to transfer tax.

3.5.4 ABC Delivery

The ABC delivery is a controversial financing construction due to the ability to alter the acquisition price between the three different parties while nothing might have changed. An ABC delivery consists of a seller (A) selling the property to the second party (B) and he sells the property within 6 months to the last party (C). For example, the building owner (A) sells the building to a developer (B) and the developer, after conceiving a plan, sells the building to the investor (C) including a plan of transformation. This is also known as a buy-develop agreement (*koop-aannemings overeenkomst*).

The main advantage of an ABC delivery is the reduction of transfer tax. If a property switches ownership multiple times within a maximum interval of 6 months, the transfer tax due is only between the difference of acquisition and sale price. In addition, financing costs of holding a vacant property is reduced to a maximum of 6 months. In traditional development (i.e. turn-key development) the building remains in ownership of the developer from acquisition until delivery which can last indefinitely, but often spans at least 1 year.

3.5.5 Crowdfunding

Crowdfunding is a relatively new development in financing constructions. The concept entails that a group of entities all provide some capital which accrues to the total amount needed. Primarily applied in the financing of startups, it has recently been transferred to real estate. This is relatively successful in the United States but seems difficult to make ground in the Netherlands (Marchand, 2016).

3.6 Financing Redevelopment

The crisis had led to changing conditions for developers and building owners (both private and institutional). The crisis can be regarded as resolved, but primarily building owners carry the burden of the credit crunch. This section elaborates on the specific changes and current situation for stakeholders of redevelopment.

3.6.1 Developers

The effects of the credit crunch are two-fold for developers. The ability to achieve financing through traditional ways (i.e. commercial financers, e.g. banks) is reduced. LTVs are reduced and most developers need to bring a larger portion of own equity. This also influences the potential home-owners of residential developments.

The ability to receive a loan relies more heavily on the type of development now than in earlier years. Commercial developments (on relatively bad locations) are perceived as high risk while residential developments are perceived as safe. The relative safe investment creates an incentive for transformation both for developers as for investors. The second effect for developers is the pre-leasing and pre-sale requirement investors impose on developers. Recently, the real estate market has recovered and demand for commercial properties is increasing, although on particular locations. The residential market is also recovering and transformations are gradually becoming more feasible, although slowly. In most cases the high book value (which is a result of the high conjuncture pre-crisis) often still poses an obstacle for transformation. Nevertheless, the changing market environment gives room for several opportunities.

3.6.2 Distressed Real Estate

The definition of distressed real estate is: “a property which is under a foreclosure order, or is advertised for sale by its mortgagee”. To clarify, the property itself is not distressed, but the underlying mortgage is non-performing, rendering it distressed. The underlying mortgage is subject to a debt service (i.e. monthly payments) and the mortgage becomes non-performing when these payments are not due for typically 90 days, the amount of outstanding debt service is called arrears. Often, the DCF of an investment property accounts for the debt service (i.e. the cash flows from the building cover the debt service), therefore the building itself may be designated as non-performing when (completely) vacant.

The property value often serves as a collateral (backing) for the loan, hence LTV. If the property value declines below the outstanding loan amount, the property is also considered distressed (*onder water*). Now when the loan matures (i.e. the end of the loan period), the loan has to be repaid, refinanced or extended. Refinancing entails obtaining another loan to take advantage of different terms or to pay off the outstanding debt on the original loan. Extending entails prolonging the loan term (often under the same terms). Any loan which cannot be refinanced or extended will be subject to other resolution strategies such as: workouts, restructuring, bankruptcies, discounted payoffs or foreclosures (Griesmer et al., 2010). Most loans will not be extended nor refinanced and thus another resolution strategy has to be chosen. Although several are mentioned, the foreclosure strategy presents an opportunity for transforming developers (Mensing & Koppels, 2013).

A foreclosure sale often fetches lower prices than its current market value. This is caused by the fact that not the building owner, but the mortgagee determines which bid will be accepted. A foreclosure sale does not imply that the outstanding loan balance, minus the revenue from selling the building, is eliminated. Rather, it serves as a first payment in reimbursing the loan, therefore the mortgagee accepts lower prices than what might be considered possible.

As of mid-2012, a quarter of the Dutch commercial bank loans are distressed (RTL, 2012). The FGH bank, the largest real estate financer of the Netherlands now known as Rabo Real Estate Finance, is assumed to have 5 billion of distressed commercial loans (Meeus, 2016). Not all of those will remain distressed or have to be refinanced, extended or any other resolution strategy applied. Nevertheless, a significant portion of the underlying real estate will remain non-performing and foreclosure will be applied in many cases, providing numerous opportunities for developers.

As can be seen in Figure 12, in 2014, distressed refinancing was only 2% of the total funds provided by capital institutes. It is however unclear, due to the discussed tax regulations, whether the new development lending also provides for transformations. It can be concluded that most property owners, assuming their buildings are still vacant, are not eligible for refinancing soon.

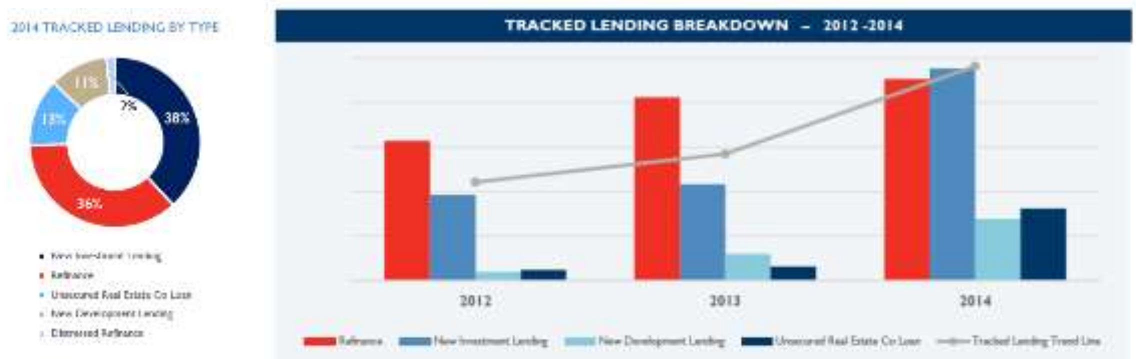


Figure 12 Tracked lending by type (Wakefield, 2015).

3.7 Conclusion

This chapter focused on the definition of value, taxation and finance in real estate. It also elaborated on the possible valuation methods for vacant real estate.

The definition of value is vague in real estate and is considered an art, rather than a science. Of importance in this research is the definition of residual value, the residual value calculation and the bathtubmodel as they will be employed in the proposed model. Residual value is the calculation often employed real estate developers in order to value vacant land or vacant properties. Building owners often value their building with a discounted cash flow. All valuation methods can value vacant properties, if applied correctly, of which some are better suited than others. However, none of the valuation methods account for mutually exclusive investments in that they compare a future scenario with the current scenario they are valuing. In other words, they do not value optionality to which the developer is faced constantly. It is based on the current state only. They can also be employed on the future state, but then it is the chosen future state only. Hence they cannot incorporate multiple possibilities.

Financing is an important issue in vacant buildings as most of the buildings are (becoming) distressed implying that the underlying loan balance is more than the current value of the building. Because vacant properties are perceived as high risk, no financing entity is willing to refinance the loan. As a result, the building owners have to look for other solutions, conversion being one of them.

One last important aspect in this chapter was the notion of taxation in real estate conversion. If a building is designated old after conversion, then 2% transfer tax applies. If designated as new, which occurs in practice, then 21% VAT applies. This can be detrimental for the financial feasibility of the project. The ruling whether a building is designated old or new is subjective and should be changed. The model provides an input to incorporate uncertainty about the tax ruling.

4 Real Options

This chapter will introduce real options. Real options provide a way to value mutually exclusive investments on the underlying, whereas traditional valuation methods cannot. These could be waiting for more information but also provide insight in active management of investment opportunities. Real options, first coined by Stewart Myers in 1977 (Myers, 1977) is the right, without obligation, to obtain something of value upon the payment or giving up something else of value. Before venturing into the world of real options, first financial options will be discussed, as real options are based upon them.

4.1 Financial Options

Real options are closely related to financial options, in fact many of the pricing methodologies (security option pricing methods, SOPM) originally used for pricing financial options were used to value real options. A financial option is **(1) the right, but not the obligation** to **(2) buy or sell** the **(3) underlying asset** of the option **(4) at or before** the **(5) maturity** of the option **(6) against a certain price.** A financial option is acquired by paying a certain price, the **(7) option premium.**

1. **The right, but not the obligation:** an option gives the holder (the owner of the option), the right, but not the obligation to buy or sell the underlying, commonly an asset (e.g. stock or bond). The fact that the holder of the option has no obligation to engage in buying or selling, he can avoid bad investments (i.e. if buying would result in a loss, he is allowed to not do so).
2. **Buy or sell:** respectively called a call (buy) and a put (sell) option, an option provides the right to buy or sell the underlying. In financial options, this is referring to the underlying security (e.g. an Apple stock) on which the option is written.
3. **Underlying asset:** the asset in subject upon which the option is written. The underlying is that which is acquired or sold when exercising (using) the option.
4. **At or before:** respectively a European or an American option.
5. **Maturity:** an option can only be exercised during its (finite) lifetime. European options can only be exercised at the maturity date (e.g. 1 day, month or year in the future, but some also span a longer period) while American options can be exercised during the whole lifetime of the option at any time. American options are therefore more valuable due to its increased flexibility.
6. **Against a certain price:** referred to as the strike or exercise price of the option. It is the amount which is paid upon exercise of the option to acquire the underlying. The strike price is (almost always) a fixed price which is pre-determined in the option contract.
7. **Option premium:** the option premium is the price of the option contract.

The option thus gives the holder the right to acquire a certain asset for a price in the future, while the current price might be higher than the pre-determined (fixed) price. Because he is not obligated to exercise the option, he has limited downside risk (i.e. the option premium) while having theoretical unlimited gain. The price evolution and pay-off structure of a call and a put option is visualized in Figure 13.

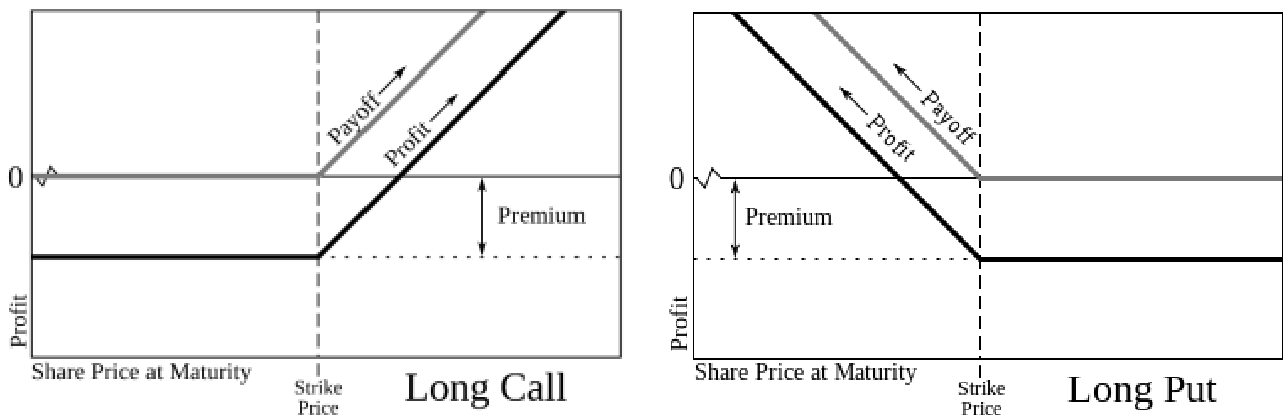


Figure 13 Payoff diagrams of call and put options (Wikipedia, 2016)

As can be seen in the pay-off diagram, if the share price (the underlying) at maturity increases (decreases), the call (put) option the profit increases (decreases) minus the premium paid. Because an option is non-obligatory, the premium is the maximum amount lost on investment, due to the fact that the holder (assuming a rational investor) will not exercise the option when the option is out-the-money. This explains why the value of an option on a project is higher in it is initial phase and decreases over time. An option can be in three states during the option lifetime: in-the-money, at-the-money or out-the-money:

Money State of Option	Equation
In-the-money (ITM)	$S > X + P$
At-the-money (ATM)	$S = X + P$
Out-the-money (OTM)	$S < X + P$

Table 6 Option money states and their equivalent equations (own table, 2016)

Where S is the value of the underlying asset, X is the strike price of the option, and P is the option premium paid to acquire the option

Next to these two basic (European and American) options, also called vanilla options, there are several other options which all have different rules. For example, a Bermuda option is an option which can be exercised at multiple pre-determined dates within the option lifetime, it is thus a combination of a European and American option. These options are called exotic options, or exotics. The pricing and valuation of exotic options is complicated and often entails (partial) differential equations or extensive simulations. Although some of these exotic options might reflect real investments in a more accurate manner[9], real option theory almost exclusively employs European and American options due to their relative ease-of-use.

Because risk is limited due to the non-obligatory nature of options, it treats uncertainty (risk) in a fundamentally different manner than traditional financial analyses, such as the DCF (Copeland et al., 2001). In fact, uncertainty adds additional value to options as the probability of ending up ITM is higher. Option analysis focusses on valuing the investment opportunity, rather than the investment itself, assuming that the investment itself can be abandoned when conditions turn sour. In addition, in case of American options, optimal exercise policies (i.e. the optimal timing of investment) are of interest, which are not in question by traditional methods (Dixit & Pindyck, 1994) which provide an additional advantage and insights, this is sometimes referred to as real options thinking.

The option price is determined by 4, and in case of an American option, 5 parameters:

Option parameter	Denoted as	Influences option value
Current market price of underlying security	S	Option value decreases when increases.
Strike / exercise price	X	Option value increases when increases.
Time to maturity	T	Option value increases when increases.
Volatility (uncertainty) of the underlying security	σ	Option value increases when increases.
Cost of holding option alive (e.g. loss of dividend)	∂	Option value decreases when increases.

Table 7 Option value determinants (own table, 2016).

4.2 Real Options

Whereas a financial option gives the holder the right to buy or sell an underlying asset, real options are basically all options available on or in real investment projects which can influence the profitability (or reduce the downside) over the lifetime of the project (or investment). The definition of real options, closely following financial options is: “the right, but not the obligation, to take an action (e.g. deferring, expanding, contraction or abandoning) at a predetermined cost called the exercise price, for a predetermined period of time – the life of the option” (Copeland et al., 2001). Real options can be used for two purposes: the valuation of flexibility to complement the traditional valuation methods and the formulation of proactive strategies.

4.2.1 Real Options as a Valuation Tool

Also referred to as the options on projects (Neely III & De Neufville, 2001) or reactive management (Leslie & Michaels, 1997). The usage of real options as reactive management is often employed as a valuation tool, finding additional value in the flexibility available to investment decision-makers (Leslie & Michaels, 1997). Reactive management is by definition, passive and primarily focusses on the ability of existing or new investments to react to changing (market) conditions and increases the value of the investment. For example, the valuation of land traditionally occurs through the residual value calculation which is based upon current market conditions. The owner of the land does however have the ability to postpone his investment to a later date when market conditions are more favorable. The ability to wait has a certain value, which should be added to the result of the residual value calculation. Mun (2002) proposes the concept of “extended NPV” (eNPV) combining option value and the value from a traditional NPV calculation. Other examples are building a different building, increasing the scale or any other feasible option which might arise. Note that NPV can be replaced with any valuation method (e.g. residual value).

[9] Real investment decisions are seldom made in a continuous (i.e. at every possible moment) manner (due to among other reasons, exercise durations) but rather in a discrete manner on daily, weekly or monthly meetings. The additional accuracy which is gained by using a Bermudan (instead of a standard European / American) option pricing method does in no way outweigh the additional computational time and complexity needed.

4.2.2 Real Options as a Strategic Tool

Proactive management, or options in projects (Neely III & De Neufville, 2001) focusses on the strategic use of real options, purposely placing and building in options in projects, but also actively influencing the option value. By allowing a project (by building in options) to dynamically adapt to changing (market) conditions the total value of the project can be increased. Adding additional flexibility in a project can significantly influence the value, for example in a commercial real estate building (D'Hulst, 2016). This flexibility, proactively incorporated remains however, reactive. As the additional built-in flexibility can only be activated when certain conditions arrive (e.g. a tenant leaves, user preferences change, or the building is obsolete and has to be transformed) the option is only worth something when these conditions appear. An option has no value (or even negative value) if not exercised (Copeland et al., 2001). In other words, the holder of the option has no influence on these conditions other than activating the option when appropriate. The use of options as a strategic (valuation) tool therefore assume that the holder of the option influences the value of the underlying. This is fundamentally different than traditional options in that the value of a financial option cannot be influenced (Copeland et al., 2001). In the example of D'Hulst (2016) the additional value is gained by the assumption that conditions will change (which they will) and therefore add significant value to the building. This other implication of real options as a strategic tool encompasses influencing the option value by "toggling" the levers which determine the option value. These are, by definition, given by the Black-Scholes framework (Black & Scholes, 1973; Leslie & Michaels, 1997): present value of fixed costs and present value of expected cash flows (also apparent in the NPV method), time to expiry, uncertainty of expected cash flows, the value lost over the duration of the option and risk-free interest rate (see Figure 14).

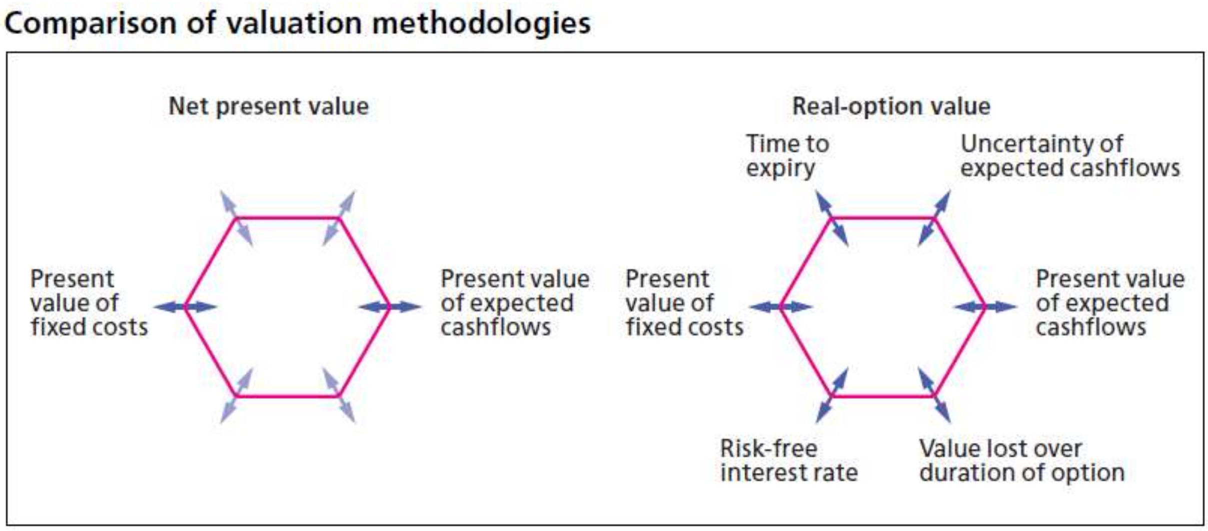


Figure 14 Value levers of NPV and Real Options (Leslie & Michaels, 1997).

By influencing these "levers", the option value increases or decreases. Or better, can be pushed in-the-money. To illustrate this. The activities of a developer before committing himself is pushing the project ITM, actively reducing uncertainty, increasing the present value and reducing the present costs before exercising the option. An example of this is a conditional sale, where acquisition occurs after the environmental permit has been approved.

The evolution of real options is described in Figure 15 and describes how real options has evolved from acknowledging the flexibility on investment (options on projects) with the flexibility in design (options in projects).

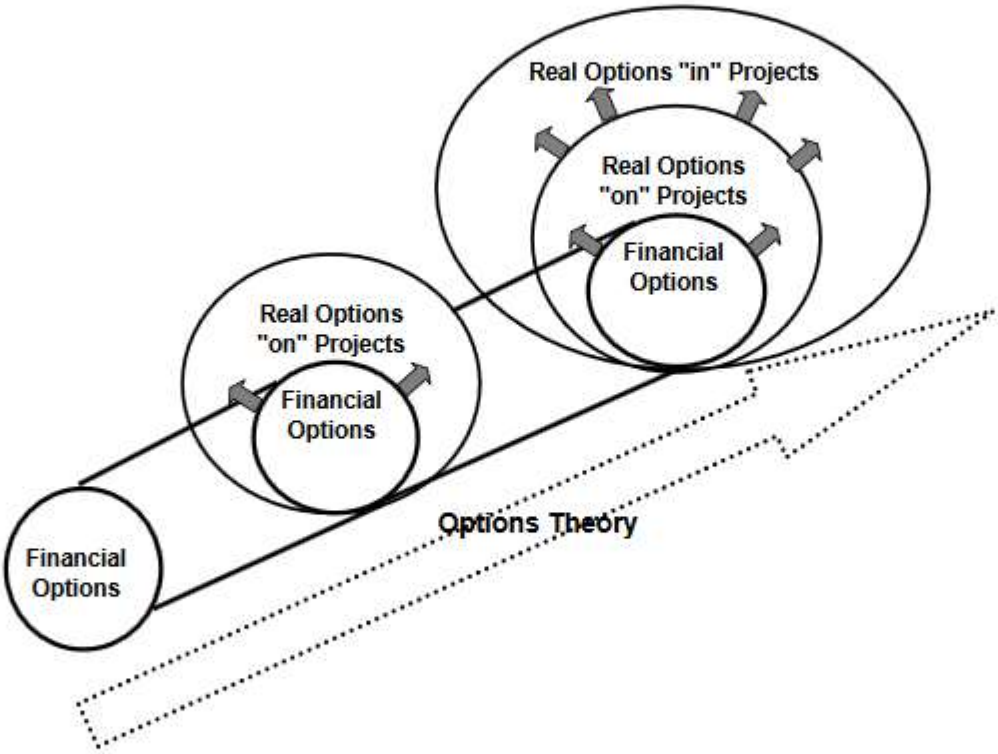


Figure 15 Evolution of real options (Wang & De Neufville, 2005)

4.2.3 Usage of Real Options

The usage of real option techniques is most suitable when (Dixit & Pindyck, 1994):

1. Uncertainty regarding the outcome which can be limited by;
2. The managerial flexibility to take action during that;
3. Totally or partially irreversible investment involving;
4. Asymmetric payoffs

The outcome of a real estate development project is inherently uncertain, even though that an observable stabilized asset value is used as a starting point, it is uncertain whether this will be achieved. Primarily due to the exposure to genuine uncertainty, the outcome is not certain, however, the developer has certain flexibility in order to react to these uncertainties. Therefore, point 2, the managerial flexibility to take action in real estate development refers to the innovativeness and response measures (which are not limited to risk mitigation measures) and opportunity capitalization which cannot be defined *a priori* but makes itself apparent over time and through the ingenuity of the developer. This all relates to the total (or partial) irreversible investment of acquisition and construction cost expenses. Because risks are limited by *a* prior defined risk mitigation measures (e.g. determining a budget for the constructor) these irreversible investments are asymmetric.

As stated by Luenberger (1997): "In fact, it is possible to view almost any process that allows control as a process with a series of operational options. These operational options are often termed real options to emphasize they involve real activities or real commodities, as opposed to purely financial commodities, as in the case, for instance, of stock options".

The usage of real options to analyze and explain the value creation in the development process by developers is therefore deemed suitable.

4.3 Types of Options

Although all choices and alternatives in a project which can be made can be regarded as real options and thus valued as such (Carmichael, 2016) literature distinguishes several categories and types of options:

1. **Single / Plain Options:** stand-alone options which are independent in a project.

i. **Delay / Deferral option:** the delay option is available to any real investment project. It entails the possibility to postpone a project to a later time period (e.g. next month, quarter or year) when uncertainty has been reduced and / or conditions (i.e. value of the underlying) might have improved.
ii. **Expand / Contract option:** the ability (to invest) to expand or contract a project which lead to an enlarged (contracted) operation.
iii. **Abandon option:** the ability to abandon a project for scrap or salvage value.
iv. **Switch option:** the ability to switch between operations (e.g. input resources) within a project.
v. **Phasing option:** the ability to divide a project in several phases instead of one moment.

2. **Compound / Combined Options:** options with embedded (in)dependent options. The dependence of different options on each other influence the valuation of said options.
    i. **Compound options:** options which become available when the preceding option has been exercised, also known as sequential options. The value of the first option is influenced by any subsequent options.
    ii. **Parallel options:** options parallel to each other. Value of any option, nor availability of any option may be or may not be influenced by any of the other options.
    iii. **Rainbow options:** options which have multiple sources of uncertainty. Often in practice, the multiple sources of uncertainty are aggregated in one uncertainty source.

4.4 Real Option Valuation Methods

All (real) option valuation methods rely on three main components to calculate the option value (Collan, 2011):

I. Model the **future value distribution:** all methods have some way to model the future value distribution or expected value by differential closed-form equations, discrete trees, simulation or subjective input.
II. Calculation of the **expected value, while mapping all negative values to zero**: an option is only exercised when the expected payoff is positive, thus all negative values are mapped to zero to calculate the option value. All option valuation methods employ some form of "feasibility" adjustment or probability of the option being exercised at the maturity date.
III. Modeling the calculation of the **present value of the expected value**: each method uses a (different) way to calculate the present value of the expected value; in particular, the discount rate used is of importance (risk-free rate, risk-adjusted discount rate, separate discount rates for benefits and costs).

The described steps lead to an intrinsic value of the option, which can be denoted as:

$$C_0 = \max(0; S - X)$$

In this equation, C_0 is the value of the option. In this equation it is clear that whenever the exercise price exceeds the underlying value (option OTM) there will be no exercise, and thus the value of the option in that particular state is 0. In other words, this process returns the current value of a decision which might be taken in another time or state by deducting the cost of this decision by the expected benefits of the decision (Carmichael, 2016).

Borison (2005) identified and tested for applicability, assumptions and mechanics the five main option valuation methods if applied to real projects. Half a decade later, Collan (2011) did the same and found due to the progression and advancements in real options research five new main real option valuation categories: partial differential equations, discrete models, MAD approaches, simulation-based and fuzzy logic based. These can be divided in two categories: the security option pricing models (SOPM) and practical real option valuation (ROV).

4.4.1 Security Option Pricing Methods

The security option pricing models in real option valuation are pricing methods originally designed to value security options on the stock market. The most famous continuous methods are the Black & Scholes (Black & Scholes, 1973), the Samuelson McKean (Samuelson, 1965) and most famous discrete methodology is the binomial (tree) option valuation (Cox et al., 1979). The Black & Scholes formula employs partial differential equations to find the option value. A disadvantage of this method is the limited applicability, as in that it can only value European options. The Samuelson McKean and binomial tree both enable the user to value American options.

The binomial tree will be used as an example[10] in order to explain the process of option valuation. The binomial tree is an advantageous method as it has the ability to value American options, and the value progression over time can be made transparent. Without introducing technical details, based on the yearly volatility of the underlying asset, a binomial tree is constructed over time. With each time step (e.g. a year), the tree extends with two arms, the up- and downward movement called nodes. Assume volatility is 10% and the initial price is 100. The first up- and downward moves results in nodes of 90 and 110, denoted as S_0u and S_0d respectively. This process is repeated until the option maturity date

[10] The following explanation is a simplification of the actual method. It serves as an explanation of the process of option valuation in the security option pricing models.

(e.g. 5 years). This results in 6 possible scenarios (nodes) at the end of the tree of which the highest is 150 ($S_0 u_5$) and the lowest is 50 $S_0 d_5$. Of these final values the strike price (75) is deducted, leaving 75 and 0. The rational investor will only exercise the option if it is in-the-money, thus nodes where the underlying value minus the strike price is 0 or less are mapped as 0. For each two adjacent nodes (150 and 140 in the example), the expected value is calculated which serves as the value of the preceding node. This process is repeated for all the nodes of the binomial tree and discounted to today which gives the option value today. The construction of the binomial tree shows what happens with the continuous process. With continuous processes, there are an infinite amount of nodes (for each infinitely small time step). The major advantage of the binomial tree approach is the actual construction of the tree. It is transparent and the option value can be calculated at each moment, allowing for the valuation and finding the optimal exercise moment of American options. A disadvantage of the binomial tree approach is that a pre-specified period of time has to be defined (the option life).

All available (real) option valuation models, indexed to category and original use, either for security option pricing (SOP) or real option valuation (ROV), to date are shown in the table below.

Category	Method (original author)	Originally Used for:
Partial Differential Equation Solution	Black & Scholes (Black & Scholes, 1973)	SOP
	Margrabe Formula (Margrabe, 1978)	SOP
	Subjective Black & Scholes (several authors)	SOP
	Samuelson & McKean (Samuelson, 1965)	SOP / ROV
	McDonald & Siegel (McDonald & Siegel, 1982)	SOP / ROV
	Custom Made PDEs (several authors)	
Discrete Event and Decision Model	Binomial Method (Cox et al., 1979)	SOP
	Decision Trees (several authors)	ROV
	Advanced Discrete Approaches (several authors)	ROV
Simulation Based	Monte Carlo Model (several authors)	SOP / ROV
	MAD Approach (Copeland et al., 2001)	ROV
	Datar-Matthews Method (Mathews et al., 2007)	ROV
	Dynamic Programming	ROV
	Distribution Fitting Approach	ROV
	Matching Approach	ROV
	Cash Flow View of Real Options (Carmichael, 2016)	ROV
		ROV
Fuzzy Logic Based	Fuzzy Black & Scholes (Collan et al., 2003)	SOP / ROV
	Fuzzy Pay-Off Method (Collan et al., 2009)	
		ROV

Table 8 Available real option valuation methods (Borison, 2005; Collan, 2011)

As can be seen, these categories all consist of several methods. The differential equation solution category has some named solutions due to their widespread application, but there are numerous other applications which rely on partial differential equations (PDEs) and are custom-made for the research subject. The use of PDEs is natural for mathematical and finance (under)graduates and any professional familiar with stochastic calculus[11]. This is however often not the case for most real estate professionals. In addition, the framework is not flexible enough to accommodate an ever-changing, project-specific arena thus for every project a new PDE has to be constructed.

Needless to say, this hinders adoption as the underlying workings of the solution remains unclear, and unusable for the user. Nevertheless, ROV was (Leslie & Michaels, 1997) and remains (Vimpari & Junnila, 2015) appealing to practitioners. Due to this constant interest in ROV methods, several simulation-based and fuzzy logic based methods were invented, primarily by practitioners.

4.5 Fuzzy Logic in Real Estate

Fuzzy logic, coined by Zadeh (1975) in 1975, acknowledges the inherent human uncertainty in describing data and estimating numbers. It is best explained by comparing it with traditional Boolean logic, i.e. crisp numbers. In Boolean logic, things are either true or not true (1 or zero) while in fuzzy logic, things could be either partly true or completely true. The value of a parameter or variable belongs to a set ranging from zero to one. For example, if Philip is either tall or short, and the distinction between tall and short lies on 180cm, and Philip is 181cm, he is tall. If Philip was 179 cm, he was considered short. Which for human logic, seems rather odd. In reality, he is somewhere in between, but the Boolean logic does not offer a way of determining this without adding a multitude of categories. In fuzzy logic, Philip, assuming he is 180cm in height is considered partly (or 0.5 short) and partly long (0.5 tall). In creating systems, Boolean logic categories, boundaries have to be crisp, while in many cases, boundaries should be soft and forgiving. Fuzzy logic enables this and reflects the human judgment process better. In risk management, the same logic is applied to the inherent uncertainty of humans and can therefore transform linguistic input ("The real estate market is bad!") in numbers

[11] The mathematical study of change which is particularly used in science, engineering and economics. It comprises differential and integral equations and solves problems which elementary algebra cannot.

and reflect (parametric) uncertain scenario estimates. The latter is employed in the Fuzzy Pay-Off method, see section 4.5.1 and enables users to value options with any type of input.

4.5.1 Fuzzy Pay-Off Method (FPOM)

The Fuzzy Pay-Off method (FPOM) is a relatively new option valuation method (Collan et al., 2009) based on fuzzy logic. Most option valuation methods employ a form of stochastic process or variables which simulate the future distribution of the project in question. This results in a detailed distribution which, in practice, is often not adding additional value in comparison to simple scenario estimates (worst, base and best). This is emphasized in real estate, where information in general is scarce due to discretion and often information asymmetry is present (Garmaise & Moskowitz, 2004; Levitt & Syverson, 2008). This is emphasized when the building's value (physical construction) increases with the underlying value of the land (Wong et al., 2012). By employing fuzzy logic, Collan et al. (2009) the projection of uncertainty can be reduced to three scenarios (minimum, base and max) which are treated as triangular fuzzy numbers where the minimum and maximum scenario have complete non-membership and the most likely scenario has full membership. In essence, the FPOM requires only three NPV, or in this case: residual value calculations to be created to price the option (the vacant real estate). Collan (2011) defines the real option value as:

"the possibilistic mean of the positive side of the value terrain weighted by the positive area of the pay-off distribution over the whole area of the pay-off distribution"

The real option value (ROV) is then calculated as follows:

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

where $\int_0^\infty A(x)dx$ is the positive area of the pay-off distribution (triangle); $\int_\infty^\infty A(x)dx$ is the whole area of the pay-off distribution; and $E(A_+)$ is the possibilistic mean of the positive side of the pay-off distribution. The possibilistic mean can then be calculated in four ways. Note that ∝ is the distance between the best guess scenario and minimal scenario and β is the distance between the maximum scenario and base scenario.

- When the whole pay-off distribution is above zero; when $0 < (a - \propto)$, then $E(A_+) = a + ((\beta - \alpha)/6)$.
- When the pay-off distribution is partly above zero, so that zero is between the minimum and base case; when $(a - \alpha) < 0 < a$, then $E(A_+) = a + \left(\frac{(\beta - \alpha)}{6}\right) + ((\alpha - a)^3/6a^2)$.
- When the pay-off distribution is partly above zero , so that zero is equal or between the best estimate and the maximum possible; when a is below zero, but $a + \beta$ is above zero ($a < 0 < a + \beta$), then $E(A_+) = ((a + \beta)^3/6\beta^2)$
- When the whole payoff distribution is below zero, then $E(A_+)$ simply equals zero.

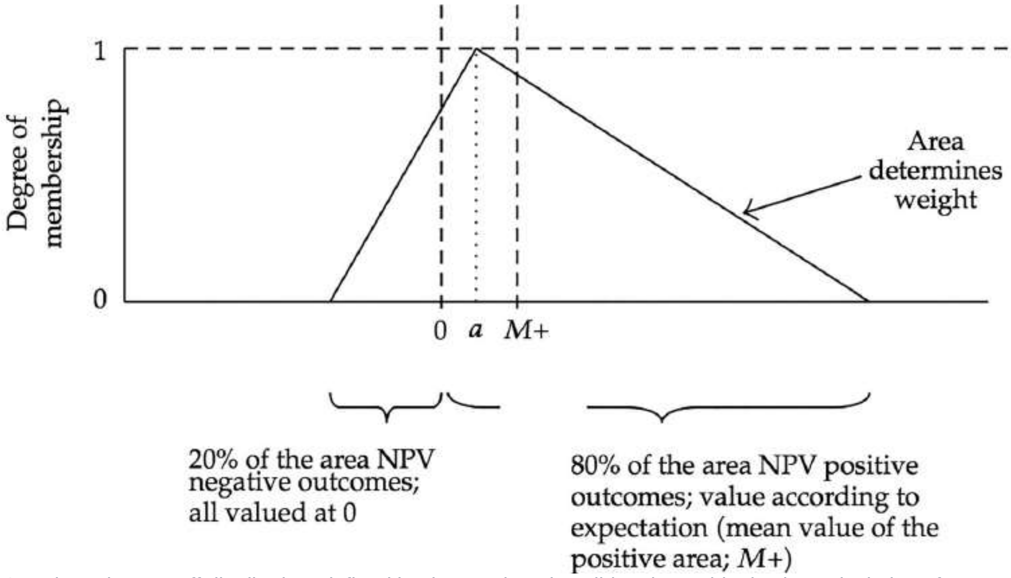


Figure 16 A triangular pay-off distribution, defined by three points describing the residual value calculation of a potential building: 20% and 80% are for illustration purposes (Collan et al., 2009).

The FPOM can be easily employed in current risk analyses. Calculation of the area of positive and negative side triangles can be done via simple geometry. The output of the FPOM are the option value and the success ratio (ratio between positive side and total area), which are both helpful indicators in the decision-making process. The three required inputs (worst case, base case and best case) are retrieved from the BKM where the worst case is the lowest value possible ("as-is"), the base case is the current mitigated option (e.g. asbestos risk is mitigated, and thus the base case increases) and the best case is the maximum option.

4.6 Real Options Research in Real Estate

There is an abundance of real options in real estate literature. Most real option literature focusses on the usage of security option pricing methods in real estate projects. Only few have taken advantage of more engineered approaches.

One of the first applications of real options in real estate was to value land under uncertainty. Titman (1985) sheds light on the speculative behavior of developers who buy vacant plots of land to leave them undeveloped until economic conditions improve. Williams (1991) is one of the first authors to acknowledge the flexibility and additional value in real estate development as options. He argues and solves analytically for, the date and scale of development and the ability to abandon the investment under the assumption of stochastic evolution of price. Foo Sing (2001) extends the nominal work of Williams by incorporating time-to-build and scale elasticity for price and cost, thereby representing the reality of real estate development *"bigger is not always better"* more precisely. In their case study, Rocha et al. (2007) find that in real estate housing development projects, the learning, phasing and abandon option are most relevant and valuable, strengthening the findings of Williams (1991). They use sale speed, rather than market price as the underlying to base their option value upon. They employ partial-differential equations (PDE) to find their solution.

Vimpari and Junnila (2014a) employ the binomial method in active residential fund management to find additional value in individual sale vs. portfolio sale in divestment strategies. His findings are accompanied with the notion that strategic considerations could influence the option value.

Grenadier (1995) uses PDEs and real options to value lease contracts based on endogenous, rather than exogenous variables. Another division of option literature in real estate involves game theory[12] and competition. Grenadier (1996) employs a PDE based option exercise game to support the "irrational overbuilding" behavior of developers in a downward market. He finds that when faced with declining demand, the seemingly irrational behavior is actually completely rational according to option theory. The negative influence of competition on the option value of optimally deferring real estate development investment has been empirically proven by Bulan et al. (2009).

Applications of real options in real estate using spreadsheet applications, such as Excel, are upcoming and commonly referred to as the "engineering approach". By valuing flexibility in a parking garage design, De Neufville et al. (2006) show how common spreadsheet software can also be employed to value optionality in (real estate) investment analysis. Barman (2007) designs the "hybrid" approach, which is a combination of security option pricing models and the engineering approach using Monte Carlo in Excel to value the phasing, scaling and deferral of a development. He finds

[12] Game theory is an umbrella term for behavioral relations in a competitive environment, first coined by Neumann and Morgenstern (1944).

that the optionality reduces the risk and increases expected value. Leung (2014) also incorporates real option valuation in Excel in addition with stochastic growth rates, valuing vertical flexibility of high-rise developments.

Another strand of literature makes use of common spreadsheet software but with different methods. In particular, the fuzzy pay-off method is employed (see section 4.5.1) to value public real estate investments (Kuittinen, 2014). Also flexibility in retrofit investments (Vimpari et al., 2014) and green building certificates (Vimpari & Junnila, 2014b) are analyzed with the fuzzy pay-off method and add additional value. Both authors acknowledge the ease of use of the fuzzy pay-off method and admire the simplistic brilliance.

In the Netherlands, research of real options is dated. Most research employs the security option pricing methods to value the optionality. Blokland (2009) questions the applicability of real options in area development and develops guidelines for the application of real options. He pinpoints the advantages of real options in comparison to decision tree analysis, by indicating that (1) there is no need for a subjective discount rate and (2) no need for subjective probabilities of scenarios, he does thereby assume that volatilities are estimated correctly. His conclusions are based upon the comparison of traditional option valuation methods and current practice, his research suggest that the most important parameter, volatility is too difficult to retrieve and thus option valuation methods have little additional value. Dijkmans (2009) employs the binomial method to value a deferral and rental agreement revision option. He concludes that to value project flexibility, direct application of option valuation methods is impossible. In addition, he acknowledges the importance of the determination of volatility. Paantjes (2013) researches the applicability of real options in public-private partnerships and concludes that the application of real options as tradable product and as tool is troublesome, but adopting a mindset with real options is quite valuable. More recently, Linssen (2015) was awarded the MSRE thesis award for his application of real options, to be specific the Margrabe formula, to measure the transformation potential of the Utrecht office market. His approach is original and testifies of (in my opinion) of a correct understanding of real options analysis, an indicative tool, rather than generative. In her dissertation, van Reedt Dortland et al. (2012) employ real options thinking in a CREM application in an healthcare environment. She acknowledges that applying real options in real estate projects, on any level, is really “another way of thinking”, whether the elaboration is quantitative or qualitative. The latest addition to date of real options in real estate is the contribution of D'Hulst (2016) who is first to (exquisitely) employ the engineering approach, using Monte Carlo, to value the adaptive flexibility in office developments. He finds significant value in this flexibility which is more than noteworthy.

Overall, it seems that in Dutch literature, there seems to be tendency of “short-sighted” application of real option valuation methods. The majority of the research analyzes a case, successfully finds some form of optionality and applies security option pricing valuation methods to value the flexibility. This results in similar findings: problematic determination of volatility of the underlying, necessity for case-specific option framing and overall increased value to the project. The usage of security option pricing methods hinders adoption, as they rely on the determination of a volatility, which is extremely difficult in real estate. The latest additions (D'Hulst, 2016; Linssen, 2015; van Reedt Dortland et al., 2012) give an indication that also in the Netherlands, real option valuation is evolving towards the essence, a new way of thinking and a new way of handling uncertainty and risk. The question arises whether developers, which can be seen as entrepreneurs, are already employing a real option mentality.

Given the overwhelming amount of real options in real estate literature, especially in development, it seems odd that real option valuation has not quite settled in business practice. Although the theoretical promise of real options is appealing, practitioners do not seem to adopt them, in particular when security option pricing methods are used. The following section will first present a short introduction to all real option models. The following section will elaborate why the adoption of real options, and in particular SOP is problematic.

4.7 Burdens to Real Option Adoption

The main obstacles for real option adoption in real estate following from the literature review are not new. Already in 2002, Oppenheimer (2002) identified 6 objections for the application of real options when security option pricing methods are used to value the real option:

1. **Option model assumptions.** The security option pricing methods are based upon the following assumptions which in real estate are often not fulfilled:
    - **Complete markets:** a market is complete when it fulfills the two following conditions: (1) negligible transaction costs and therefore perfect information, and (2) there is a price for every asset in every possible state of the world. The first is not true, as transaction costs in real estate are relatively high (at least 2% transfer tax). The second condition is also doubtful, real estate market are inefficient and thus no objective pricing can be made, see objection 2.
    - **No arbitrage opportunities or fully diversifiable risk:** considering real estate development in particular is an opportunity business, there is a high chance that arbitrage opportunities exist. Fully

diversifiable risk might, but is doubtful, be true if option valuation methods are used by huge REITs. The portfolio of private real estate investors is probably insufficient to fully apply diversification.

- **An observable underlying (twin) asset that has perfect correlation or constant correlation with the asset in question.** See objection number 5.
- **Log-normal returns for the underlying asset.** Buildings can produce a negative cash flow.
- **A known and constant mean return and variance.** True for assets with a perpetual tenant. Real estate development becomes more certain over time. In other words, the mean return and variance changes over time and thus the option value also changes over time.
- **A known and constant risk-free rate.** Although also applied as element of the discount rate, even risk-free rates are not constant. This assumption can therefore be relaxed.
- **A well-defined mathematical process that the underlying asset follows in time.** Additional research is needed to validate whether real estate markets follow a mathematical process, research suggests that real estate markets should be modelled with a weak form of mean-reverting stochastic processes or "bounded" random growth (Wheaton et al., 2001).

2. **Real estate market inefficiency[13].** Private transactions, infrequent transactions (especially in low-conjuncture), costly fees, information asymmetries and many regional markets add up to an inefficient market. Real estate markets prohibit investors with the ability to fully diversify risk.
3. **Interdependent options.** A real estate project consists of a multiple of options which might influence each other. The required mathematics to model this interdependency quickly becomes intractable.
4. **Proxies for real estate returns.** In former research, REIT returns seem to have a stronger correlation with stock market returns than with actual real estate returns on object level (Han & Liang, 2009). Therefore, using aggregate real estate indices to value options on individual real estate assets yields unreliable results.
5. **Uniqueness of real estate assets.** Real estate is fundamentally different than stocks or bonds by its uniqueness.
6. **Foregoing dividends and time to exercise.** Loss of earnings is similar to dividend-paying stocks, and thus is not a direct obstacle for application. However, the cash in- and outflow of a real project are often much more complicated than in case of an ordinary option. Where in case of a regular option, the payoff is immediate upon exercise. In real options, there is often a time-to-build and positive cash flows are received a certain period after exercise.

The abovementioned objections can probably all be solved by increasing the mathematical complexity when using security option pricing methods. In doing so the model becomes intractable, especially in the heuristic practice which is characteristic of real estate (or any other business than finance). Interestingly, academics beg to differ, in that they keep expanding their models to mimic real estate behavior and finding satisfactory results on paper but keep drifting further away from practice. Their models are criticized due to the complex level of mathematics, unknown terminology and black box approach (Borison, 2005).

The proposed fuzzy pay-off method avoids all these assumptions and allows for any kind of process to model the underlying. As a result, the option value might become a subjective value but as this is the case for all valuations in real estate this does not impose a problem. In addition, the fuzzy pay-off method, when used correctly, yields similar results to the traditional security option pricing models: Black & Scholes and binomial option valuation (Collan, 2011). In other words, if practitioners (experts) are able to provide some form of future distribution of the underlying asset, whether it is stocks, bonds or any other valuable asset (i.e. real estate), simpler option valuation methods may be employed while providing the same results.

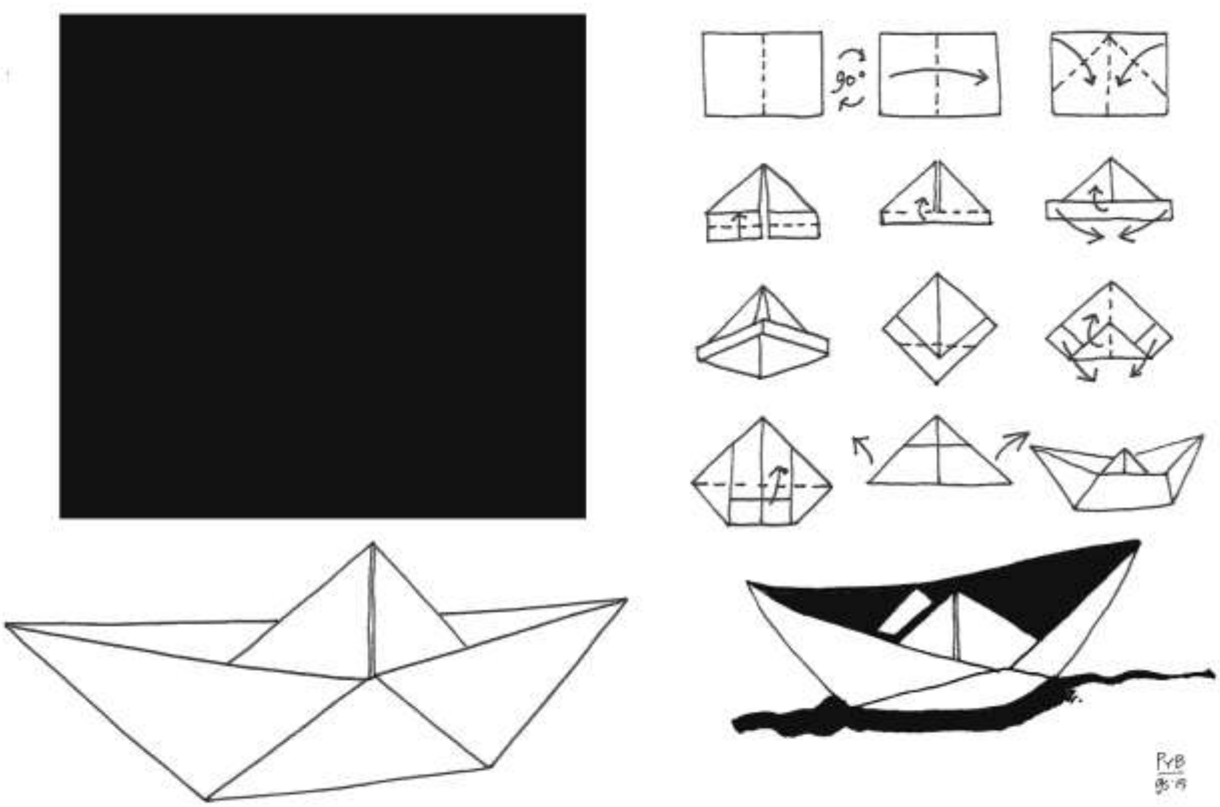
4.8 Conclusion

This chapter introduced and elaborated on real options. A real option is the right, but not the obligation, to undertake an action, before or at a predetermined date for a certain price. In the essence, every option or form of flexibility can be viewed as a real option and therefore be valued as such. The development process, in which the developer is the decision maker and strives for the best possible solution for each option, can be seen as a continuous series of options.

This implies that additional value is found throughout the development process. By incorporating Monte Carlo simulation to create payoff distributions of each individual value increment step in the development process, and finding the option value with the FPOM framework, of each step the value of flexibility, or better, the value of decision-making by the developer can be found. This can shed light in the entrepreneurial character, or basic decision making in general, of the developer which is not found by normal risk analysis.

[13] Market efficiency implies that the price of an asset fully reflects all the available information.

Part III Method & Results



5 Methodology

This chapter starts off with a quick recap of the literature research and the proposed method to find the option value of conversions of commercial real estate buildings. The model will be described as well as the input variables, decision variables, constraints and objectives for optimization. Two strategies will be tested, the traditional (linear) process and the upfront sale to investor.

5.1 Recap

The development process can be seen as a series of options for the developer. It is assumed that for each option, the best possible decision is made. In traditional valuation methods, uncertainty is regarded as risk and accounted for by decreasing the residual value of the building. Because a developer has significant influence on this process, it is argued that due to optionality, the project value should be extended by the option value. This can be argued as the true price for a vacant building and the value can be found for each individual step of the development process. In addition, with the option framework it is possible to find the optimal acquisition moment. That is, when the option value of the property equals the expected building value.

5.2 The Model

The model is an extension on the Bathtub-model (Sakkers & Boswinkel, 2015) which is a residual value calculation with risk explicitly separated from the rest, and by incorporating the FPOM. The model exists of two simple tabs (input tab and option calculation tab). This chapter is best read with the appendices of the model on the side.

Light blue text refers to cells which must be filled in by the user. Light green text is linked to a user-input cell. Green filled cells are assumptions. Orange cells are linked to the option calculation tab. Dark blue cells are forecast cells used for the Monte Carlo simulation. Dark green cells are fixed and linked to a corresponding cell. Red cells are decision variable cells used for the optimization process. The model is usable with and without Monte Carlo simulation. The light blue cells are used for the option value calculation.

5.3 Input Tab

In the input tab all general data (e.g. date, project number) and object-specific data (e.g. size of the building and construction year) must be given (the size of the base case building is **5500 m²**. After this data has been provided input must be given about development assumptions and market assumptions (further referred to as MVars and DVars, and together as MDVars) have to be made for the following variables:

UNCERTAINTY NOT UNDER INFLUENCE OF DEVELOPER			
Variable	Min	Base	Max
Development Assumptions			
Asbestos Removal Costs	0	10	25
Demolition Costs	15	25	30
Transformation Costs	800	900	1000
Additional Costs	-	26%	-
Construction Period	12 months	14 months	16 months
Development Period	5 months	6 months	7 months
Market Assumptions			
Current Selling Price	€2900 / m²	€3000 / m²	€3100 / m²
UFA/GFA[14]	0.75	0.77	0.78
Financing Interest Rate	0.5%	0.75%	1.00%
Indexation	1.75%	2.0%	2.50%

Table 9 Base settings for MDVars

The input given about costs and markets entail uncertainties which cannot be influenced by the developer. Market and development uncertainties do influence the option value and must therefore be taken into account. The remainder of the tab calculates the project result.

[14] Has primarily influence on revenue and thus included in market assumptions.

5.4 Option Calculation Tab

In the option calculation tab, the outcome of the BKM (which is also shown in this tab) is used as the input variables for the option calculation itself. The value of the option in the current state is given as well as the success rate of the project. Note that the success rate is only applicable when the minimum scenario is negative, which is not observable in all cases. Input has to be given about the initial uncertainty of the following uncertainty categories which are under influence of the developer:

	UNCERTAINTY UNDER INFLUENCE OF DEVELOPER		
	Uncertainty Category	**Mean**	**Deviation**
1	Asbestos / Contamination	Linked to Input Tab	-
2	Design	4%	0.8%
3	Neighborhood & Politics	3%	0.6%
4a	Zoning Plan	25%	Fixed
4b	Environmental Permit	4%	0.8%
5	Construction	8%	1.6%
6	Sale (Investor)	3%	0.6%
7	Sale and Letting (Consumer)	2%	0.4%
8	Tax	5%	-
	Total	**27%**	

Figure 17 Base settings for DVars

The uncertainty categories are assumed to log-normal distributed and capped at the minimum value (implying that when accepting, the risk will occur and with a long tail). The standard deviation is set at 20, 10 or 0% of the mean, depending on state of the decision variable. The choice for log-normality is made because risks might be bigger than expected (reflected by the tail of the log-normal distribution) due to unforeseen. In addition, the use of log-normal distribution is in accordance with (real) option valuation (Collan et al., 2009).

On the Option Calculation sheet the minimal value, the adjusted building value (ABV) and the maximum value as calculated by the BKM are given. Next to these three values the option value is given.

The decision variables are manually operable but are also optimized. When decision variables are adjusted, part of the direct risk is removed from the project and the remainder is less uncertain. Some decision variables have two settings. This increases the option under reduced uncertainty and the option value directly. When manually operated, the result is directly observable. In order to incorporate the market and development uncertainties, a Monte Carlo simulation has to be run.

The option value is a non-linear process meaning that, although it will start off higher because it acknowledges that the maximum scenario might be reached over time, it will gradually grow slower than the base case value (see Figure 18) when uncertainty is reduced. At a certain moment, the option value and value under reduced risk will collide, indicating the optimal moment to invest (i.e. acquire the building) and under what conditions. These conditions can be used for the risk- profit sharing agreement.

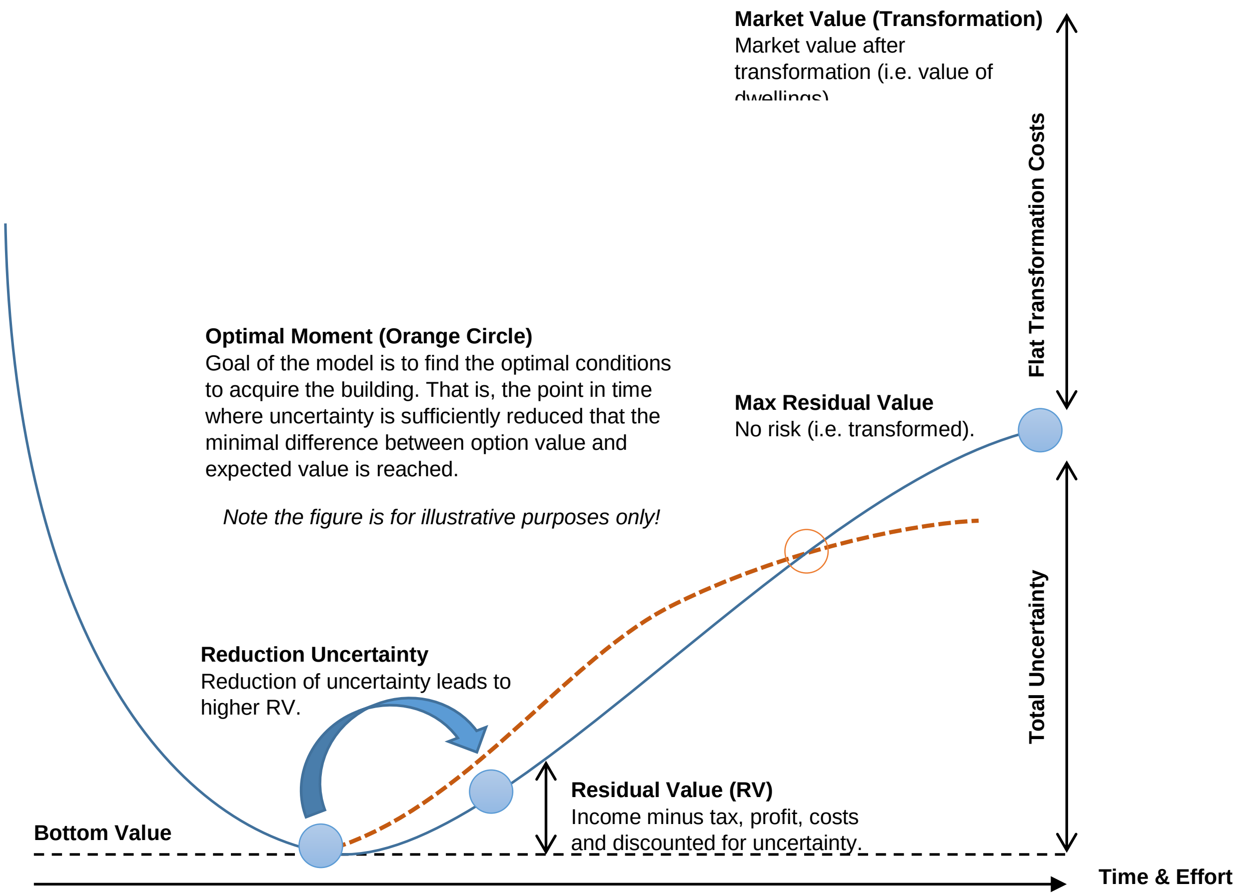


Figure 18 Residual value, uncertainty and the ROV boundary (own illustration, 2016).

5.5 Correlations

There are three correlating assumptions in the non-influenceable part of the model of which two can be modified in the **Input tab** and one is set as an assumption by the author.

Correlating Variables	SalePrice	TransformationCosts	DemolishingCosts
Sale Price	-	0.7	-
TransformationCosts	0.7	-	0.5
DemolishingCosts	-	0.5	-

Table 10 Correlation of variables.

The need to correlate the endogenous variables is not needed in that these risks are calculated as a percentage of the market and development variables. Therefore, a higher risk will also be apparent when a higher number is taken from these assumptions.

5.5.1 Zoning Plan Change Value

For the additional value created by the zoning plan change an assumption is made based on basis of the *Grondprijzenbrief* of The Hague but all municipalities provide this document. In this “letter” the actual ground quotes for all types of dwellings (categorized on floor area UFA and free market price or investment value) are defined by the municipality as a percentage. The selected percentage (25%) is an average and is used for simplification purposes. The *Grondprijzenbrief* provides the information for all types of properties (i.e. single- and multi-family) and should be employed when doing further (extensive) analysis. For the purpose of this model the average is deemed sufficient. In the original BKM model, and in most cases the zoning plan change has already been made and thus has no influence on the acquisition price. In general, when the zoning plan change has not been made, the building (if structurally vacant) has almost no value in a traditional analysis (Sieverink, 2014). The option theory however sheds some light on this and will be discussed in the results.

5.5.2 Transformation & Additional Costs

The base case transformation costs are based upon the work of (Mackay, 2008) which state that the average construction costs (ex. VAT) are €759 / m^2. He categorizes the costs on construction year finding as follows:

Construction Year	Average Building Costs €/m^2
Before 1970	770
1970 – 1979	681
1980 – 1989	815
After 1989	936

Table 11 Transformation costs of conversion (Mackay, 2008).

Nevertheless, construction costs may vary significantly per project (Bijdendijk & Alderliesten, 2016) and therefore the subjective input is perhaps more applicable. Of interest is the deviation at initiative versus the deviation at a later stage in the feasibility analysis (which is done by reducing uncertainty). The base case for additional costs is set at 26% (Gehner, 2011).

5.5.3 Deviations in Decision Variables

The deviations in the decision variables are primarily based upon the table provided by Schmidt (2012) with input from IGG (cost estimators in practice) and shows that cost estimates uncertainty decreases from initiative phase to definitive design. These estimate ranges are applied on the following aspects: design costs, construction costs and additional costs. It is also assumed that the same range can be applied to the form factor. For the actual deviations, the initiative phase is taken for the min scenario (worst) and the preliminary for the reduced scenario. The no uncertainty scenario assumes that worse situations are transferred to the responsible party and the possible betterment remains with the developer. The sketch design has been omitted as it generally does not entail contracting other parties.

Intiative	Sketch Design	Preliminary Design	Definitive Design
20%	15%	10%	5%

Table 12 Cost estimate deviations (Schmidt, 2012)

5.6 Decision Variables

The model consists of eight decision variables which have multiple settings shown in *Table 13 Decision variables and settings.*Table 13. The numbers in blue are user input. Deviations are described below.

N	Aspect	Mitigation	Settings	Ass.	SD	Inflicts	Example Conditions
1	Asbestos	0 (Accept)	0	10	25	Costs	Asbestos risk for developer.
		1 (Transfer)	0	0	0	Costs	Building not acquired with asbestos.
2a	Design	0 (Accept)	0	4%	0.8%	Costs	Acquisition in sketch phase.
		1 (Reduction)	0.5	4%	0.4%	Costs	Acquisition in preliminary design phase.
		2 (Transfer)	1	0	0	Costs	Acquisition when design has been finished.
3a	Neighborhood Approval	0 (Inform)	0	3%	0.3%	Revenue	Provide information.
		1 (Participate)	0.5	3%	0.6%	Revenue	Setup meetings and incorporate some ideas.
		2 (Incorporate)	1	0	0	Revenue	Design and execution led by demands of neighborhood & politics.
4a	Zoning Plan[15]	0 (Not Approved)	-25%			Revenue	Zoning plan not approved.
		1 (Approved	0%			Revenue	Zoning plan approved.
4b	Environmental Permit	0 (Not Granted)	0	4%	0.8%	Costs	Environmental permit not granted.
		1 (Granted)	1	0	0	Costs	Environmental permit granted.
5a	Construction	0 (Accept)	0	8%	1.6%	Costs	Acquisition before construction.
		1 (Reduction)	0.5	4%	0.8%	Costs	Construction risk shared.
		2 (Transfer)	1	0	0	Costs	Construction risk transferred.
6	Sale	0 (Accept)	1	3%	0.6%	Revenue	Sale occurs after completion of the development on the free market (turn-key).
		1 (Reduce)	0.5	1.5%	0.3%	Revenue	Sale before construction but without upfront investor at acquisition.
		2 (Transfer)	0	0	0	Revenue	Sale before construction with upfront investor (acquisition occurs under disposal to investor).
7	Letting	0 (Accept)	1	2%	0.4%	Revenue	All sale to consumer risk with developer.
		1 (70% pre-sold/let)	0.5	1%	0.2%	Revenue	Construction starts at 70% presold or prelet.
		2 (100% pre-sold/let)	0	0	0	Revenue	Completely pre-let before acquisition.
8[16]	Tax	0 (No Tax Ruling)	-19%		19%	Revenue (Tax)	No upfront tax ruling (21% VAT or 2% might apply).
		1 (Tax Ruling)		2%		Revenue (Tax)	Tax ruling designated as old (2% transfer tax applies).

Table 13 Decision variables and settings.

There will be a performance of three kinds of analyses with the decision variables: frozen, unfrozen and frozen during process. The first implies that all market and development variables (MDVar) are frozen (i.e. set to base case and do not act as a distribution) from the start. This is done to observe the influence of a developer on the optimal solution. The second situation is where all assumptions are unfrozen. The last implies that the specific M&DVar will be frozen at the moment the specific risk is removed. For example, if design risk is set to 1, the form factor variable is frozen. No alterations are made on the base case scenario which does occur in practice (e.g. the final form factor is known). The variables which will be frozen on which risk step are described below.

[15] Classified as veto criteria and therefore optional.

[16] Classified as veto criteria and therefore optional.

Decision Variable Reached	Corresponding Assumption(s) Frozen
Construction	Interest Rate, Demolishing Costs, Transformation Costs, Development Period
Design	Form Factor
Sale to Investor	Current Sale Price, Indexation
Sale to Consumer	Construction Period

5.7 Moments of Acquisition

The model distinguishes thirteen moments for the linear process at which the building can be acquired and will be described in the table below and which assumptions are frozen.

Phase	Description	Frozen Assumption(s)
1	Acquisition as-is, where-is including all risk.	
2	Acquisition after asbestos risk has been mitigated.	Asbestos
3	Acquisition after preliminary design has been finished.	
4	Acquisition after final design has been finished.	UFA/GFA
5	Acquisition after politics and neighborhood are invited to participate.	
6	Acquisition after ideas and suggestions from politics and neighborhood are incorporated in development.	
7	Acquisition after environmental permit has been approved.	Interest Rate, Demolishing Costs, Transformation Costs and Development Period.
8	Acquisition after construction risk is reduced.	
9	Acquisition after construction is completed.	Construction Period
10	Acquisition after letter of intent is signed by investor.	Sale Price and Indexation.
11	Acquisition after disposal is made.	
12	Acquisition (or disposal in case of building owner) after dwellings are partly sold to consumers.	Construction Period.
13	Acquisition (or disposal in case of building owner) after dwellings are all sold to consumers.	

Table 14 Moments of acquisition for linear process.

Due to simplification purposes, some of these phases and steps contradict each other. For example, sale to investor occurs before the dwellings are let or sold to consumers. It therefore refers to the risk of letting which might be resolved in an earlier stage. This is simulated in the second case (presale to investor).

6 Results

This chapter will analyze the results of the cases. Primarily the key findings will be discussed, and afterwards put into perspective of the existing literature. Results are created by usage of the Monte Carlo Crystal Ball add-in and can be found in the appendix. On basis of the results and reflection with literature, the conclusions can be made. It should be noted that the model can also be employed without the Monte Carlo Crystall Ball add-in. The usage is then however excluding the simulation process.

6.1 Strategies

Modelling the real estate development process is due to its non-linear character and interrelated variables hard to model (if not impossible) (Gehner, 2011). Therefore, the analysis will be initially done by determining two strategies: the traditional process and the upfront sale to investor. In the former, the developer acquires a piece of property, makes a design, applies for an environmental permit, start construction and sell the building to an investor after the building has been let. In the latter, the building is sold upfront to an investor (after asbestos is excluded and the design is finalized), after which the other phases follow. Both cases will be analyzed in a frozen, unfrozen and bad market case. Note that all strategies are done under the assumption that zoning plan and tax are fixed.

6.2 Approach

In the linear and pre-sale strategy cases the approach to find and analyze the option value is:

1. Define assumptions for input and uncertainty variables.
2. Set decision variables to the next step according to setup of strategy.
3. Run Monte Carlo for the option value (FC(OptionValue)), chosen option (FC(ValueOptionReduced)) return when risks are managed right (FC(NoRisk)) and when all went wrong (FC(AllRisk)).
4. Extract min, max and median[17] for the option forecasts and 95% CI for the adjusted building value (ABV).
5. If last step go to 6, otherwise go to 2.
6. Finish.
7. Analyze.

The results per strategy and case will be:

- The **optimal acquisition** moment for a risk-seeking, risk-neutral and risk-averse developer.
- The **added value** by the optionality and decision making of the development process.

6.3 The Traditional Development Process

The linear case assumes a traditional development process as described in literature. A potential development is found, land is acquired, the design is made, and the application for an environmental permit is filed. After approval and possible pre-sale (pre-let) the construction commences. After construction the completed development is either sold to an investor or sold on the free market. In this case, presale and sale resemble the total sales risk. The objective is to find the situation where the option value is equal (or around) the option with reduced risk as it indicates that acquisition is optimal. In this respect it deviates from the traditional process in that acquisition is not done initially, but is the target of the model, to find the optimal value.

Uncertainty	1	2	3	4	5	6	7	8	9	10	11	12	13
Tax	1	1	1	1	1	1	1	1	1	1	1	1	1
Presale	0	0	0	0	0	0	0	0	0	0	0	0.5	1
Sale	0	0	0	0	0	0	0	0	0	0.5	1	1	1
Construction	0	0	0	0	0	0	0	0.5	1	1	1	1	1
Permit	0	0	0	0	0	0	1	1	1	1	1	1	1
Zoning Plan	1	1	1	1	1	1	1	1	1	1	1	1	1
N&P	0	0	0	0	0.5	1	1	1	1	1	1	1	1
Design	0	0	0.5	1	1	1	1	1	1	1	1	1	1
Asbestos	0	1	1	1	1	1	1	1	1	1	1	1	1

Table 15 The development process and possible value increments (green indicates change per step, grey indicates fixed).

[17] Using min and max instead of 95% CI is in line with fuzzy numbers and real option theory (Collan, 2011).

6.3.1 Traditional (Frozen)

Figure 20 shows the results of the frozen base case in a traditional development process with regard to the optimal acquisition of the property.

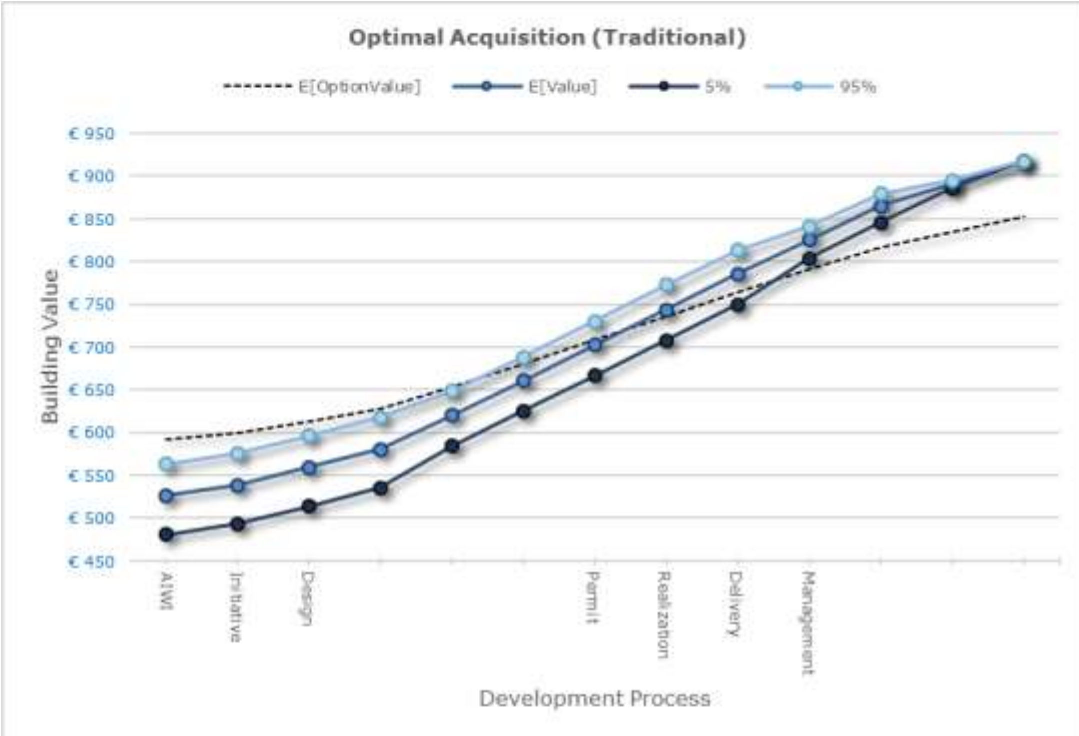


Figure 19 Optimal acquisition in traditional development process (own ill.)

In the figure, the Y-axis refers to the value of the building over the development process in the X-axis from AIWI until project expiration (i.e. stabilized asset). The black dotted line refers to the option value and indicates when acquisition is optimal. The blue lines (from light, medium and dark) is the value distribution of the project by the MCA.

From these results, it can be concluded that the risk-neutral developer would acquire the building when the environmental permit has been received and construction can commence. For a risk-seeking developer (light blue line), acquisition after a design has been finalized is optimal. A risk-averse developer would acquire the building after it has been constructed.

In Figure *20* the optionality value is exhibited. The Y-axis refers to the building value and the X-axis refers to the project timeline. The bottom dark green line indicates the expected value by a traditional residual calculation, the green line indicates the traditional residual calculation extended by the value of optionality (i.e. the option value of each stage) and the black dotted line shows the value evolution of the option.

As can be seen, the expected value due to optionality is higher than the expected value of the project, indicating that if rational decision-making is employed (i.e. limiting downside risk, exploiting upside potential) the project result would most likely be higher than what is expected in a traditional calculation which assumes passive behavior of the developer. In addition, three clear peaks (indicated by the orange circles) can be observed in the design phase, prior to the permit and prior to realization. These indicate that the option value is highest and suggest that developers can add most value at these specific moments.

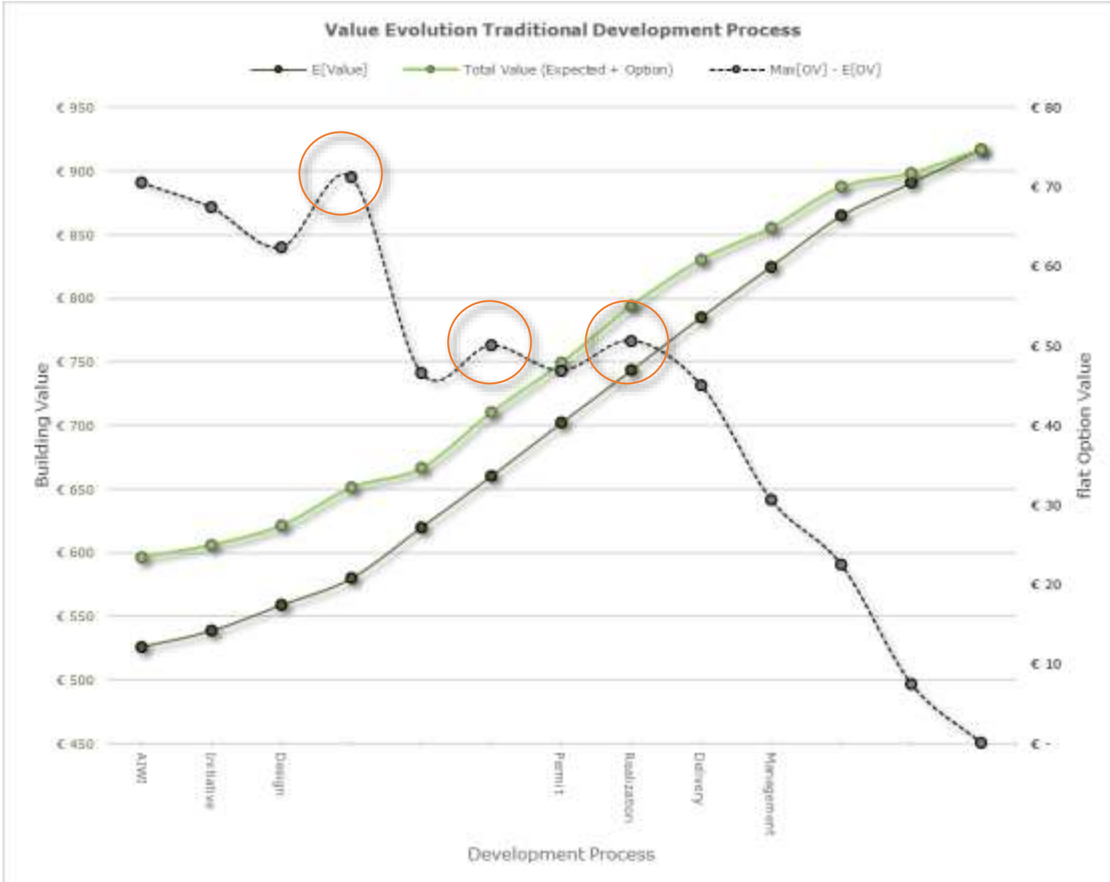


Figure 20 Value evolution and optionality value (own ill.)

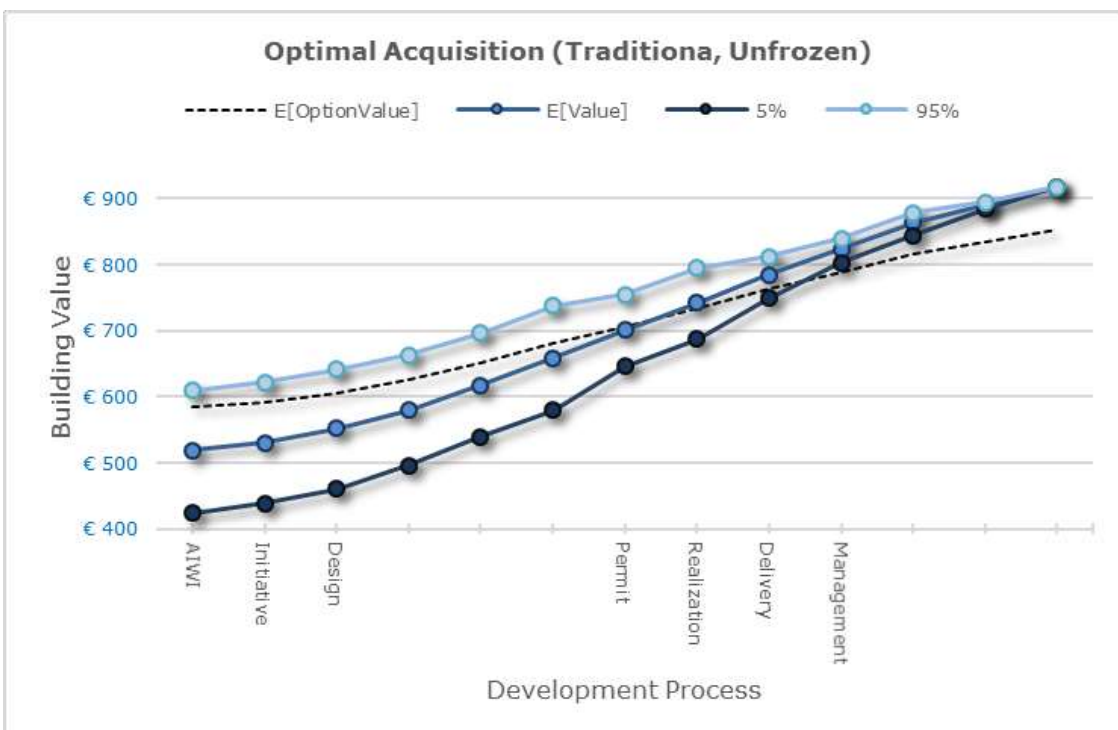


Figure 21 Traditional process, frozen by risk (own ill.)

6.3.2 Traditional (Set By Risk)

In the traditional process, unfrozen, set by risk the exogenous variables are frozen when the developer has reached a certain milestone in the project (e.g. finalized design freezes the form factor). The method by which this is done is described in chapter 5. In Figure *21* the optimal acquisition moment is depicted. Comparison with the frozen case indicates that the acquisition moment for a risk-neutral developer remains the same, at grant of the environmental permit. The risk-seeking developer however would acquire the building AIWI as his perceived value is already higher than the option value.

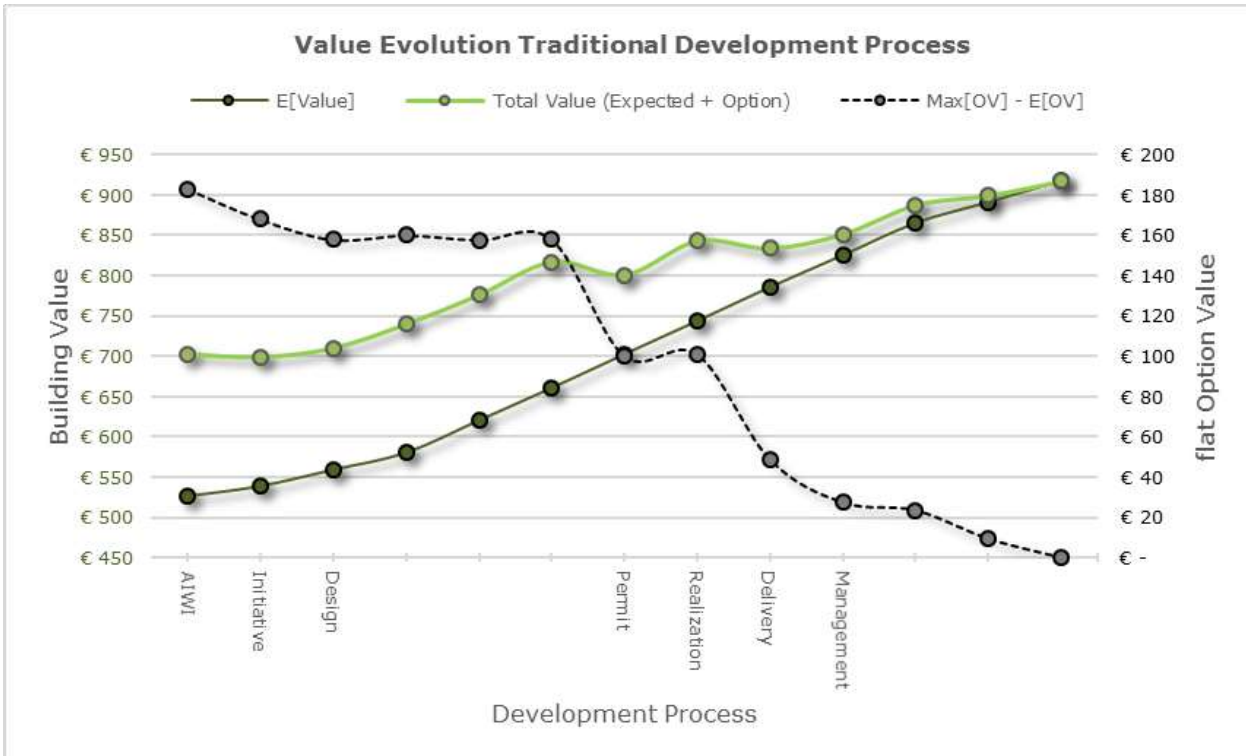


Figure 22 Traditional development process, set by risk (own ill.)

The effect of the inclusion of variables which are not under the influence of the developer become more apparent in the graph representing the value of optionality, see Figure 22. Four main differences emerge:

- The overall option value is almost a factor 2 higher.
- The option value is highest at AIWI.
- Instead of generating peaks, the option value remains flat at value-generating moments (e.g. design, permit).
- The management phase has a lower option value, but remains flat instead of decreasing.

6.3.3 Traditional (Bad Market)

The last case study is the traditional process set in a bad market. In the following tables, the MDVars which are changed to represent a bad market case are shown. It is assumed that, in a bad market, primarily the sales are at risk and therefore these are adapted. In addition, the total uncertainty regarding the sale price is wider. Construction costs are assumed to be lower due to price-suppressing market conditions. The construction risk is perceived higher as the constructor might go bankrupt during the development process. Last, the financing interest rate is at a higher level and indexation is lower.

EXOGENOUS VARIABLES			
Variable	Min	Base	Max
Development Assumptions			
Transformation Costs	750	800	950
Market Assumptions			
Current Selling Price	€2300 / m^2	€2500 / m^2	€2600 / m^2
Financing Interest Rate	1.5%	2.0%	2.5%
Indexation	1.5%	1.75%	2.00%

	ENDOGENOUS VARIABLES		
	Uncertainty Category	**Mean**	**Deviation**
5	Construction	10%	2.0%
6	Sale (Investor)	6%	1.2%
7	Sale and Letting (Consumer)	5%	1.0%

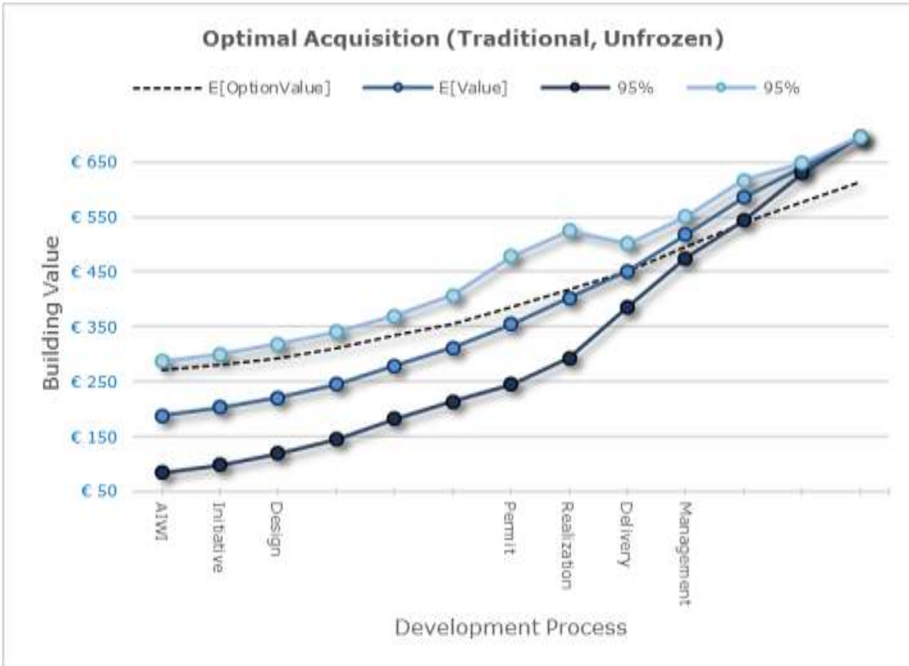
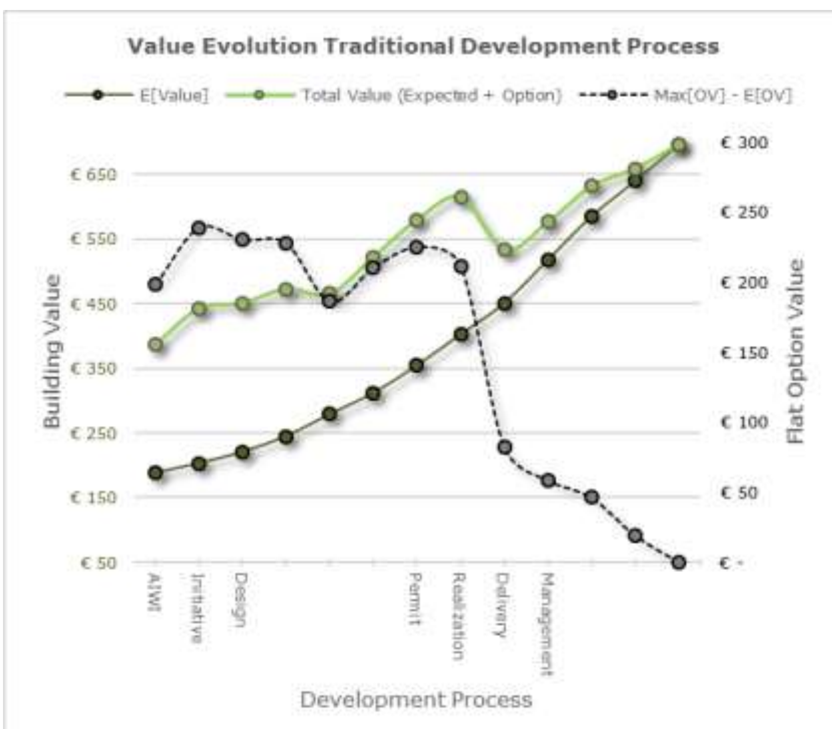


Figure 23 Optimal acquisition in a bad market in traditional process (own ill.)

Optimal acquisition (see Figure 23) in bad market case shows two major changes in comparison to the good market case: the moment of acquisition has been postponed for both the risk-neutral and risk-averse developer. The second, is that although risks have been significantly adapted, the progression of option value remains stable.



The traditional bad market case shows a completely different value progression as compared to the normal market case. In comparison to all other cases, four main differences occur:

- The option value in a bad market is higher than in a normal market.
- The value progression of the option value is more volatile, especially when major risks are excluded (i.e. construction risk).
- The option value remains highest in the initiative and prior to realization.
- The option value is no longer highest at AIWI.

6.3.4 Presale (Frozen)

The upfront sale to investor entails finding an investor who is willing to buy the building on basis of a preliminary or final design. As most of the uncertainty will be removed from the project upfront, it is a feasible strategy for fee-developers and with bad market conditions. The steps taken are described in the table below.

Uncertainty	1	2	3	4	5	6	7	8	9	10	11	12	13
Tax	1	1	1	1	1	1	1	1	1	1	1	1	1
Presale	0	0	0	0	0	0	0	0	0	0.5	1	1	1
Sale	0	0	0	0	0	0	0	0,5	1	1	1	1	1
Construction	0	0	0	0	0	0	0	0	0	0	0	0.5	1
Permit	0	0	0	0	0	0	1	1	1	1	1	1	1
Zoning Plan	1	1	1	1	1	1	1	1	1	1	1	1	1
N&P	0	0	0	0	0,5	1	1	1	1	1	1	1	1
Design	0	0	0.5	1	1	1	1	1	1	1	1	1	1
Asbestos	0	1	1	1	1	1	1	1	1	1	1	1	1

Table 16 Presale development process (green indicates change per step, grey indicates fixed).

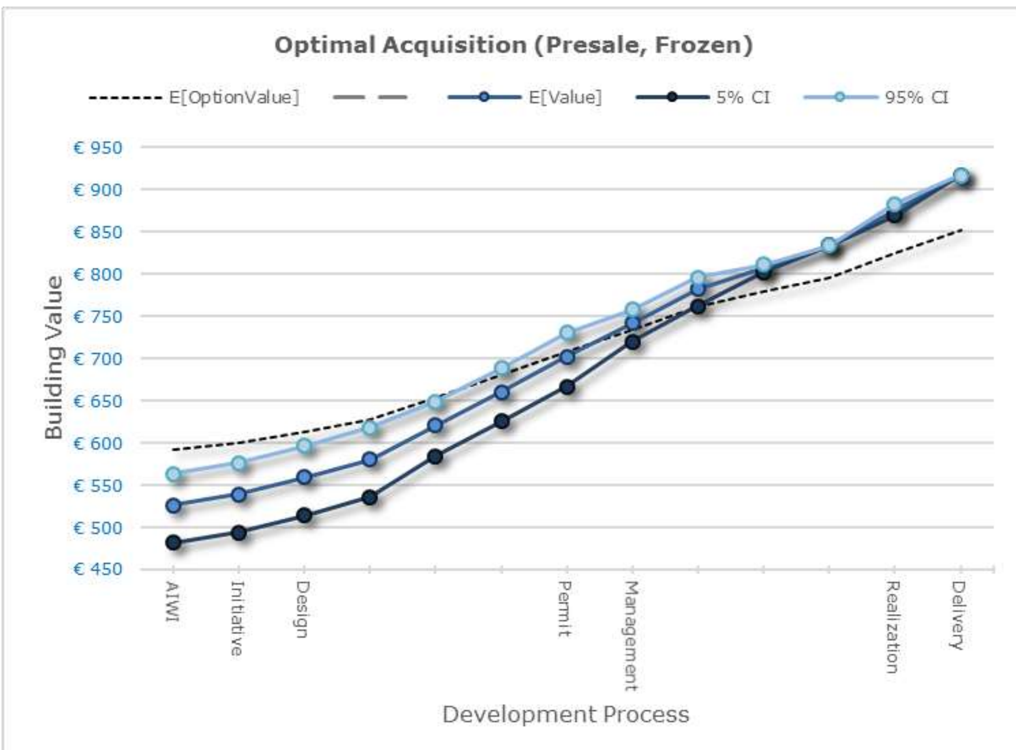


Figure 24 Optimal acquisition in presale, frozen (own illus.)

In a presale scenario, one important change for the optimal acquisition moment (see Figure *24*) can be observed in that the construction part is separated from the remainder of the project. Optimal acquisition occurs at approval of the environmental permit for the risk-neutral developer. The risk-seeking developer acquires the building at the same stage, while the risk-averse developer will acquire the building the building after it has fully sold (i.e. acquisition contract has been signed).

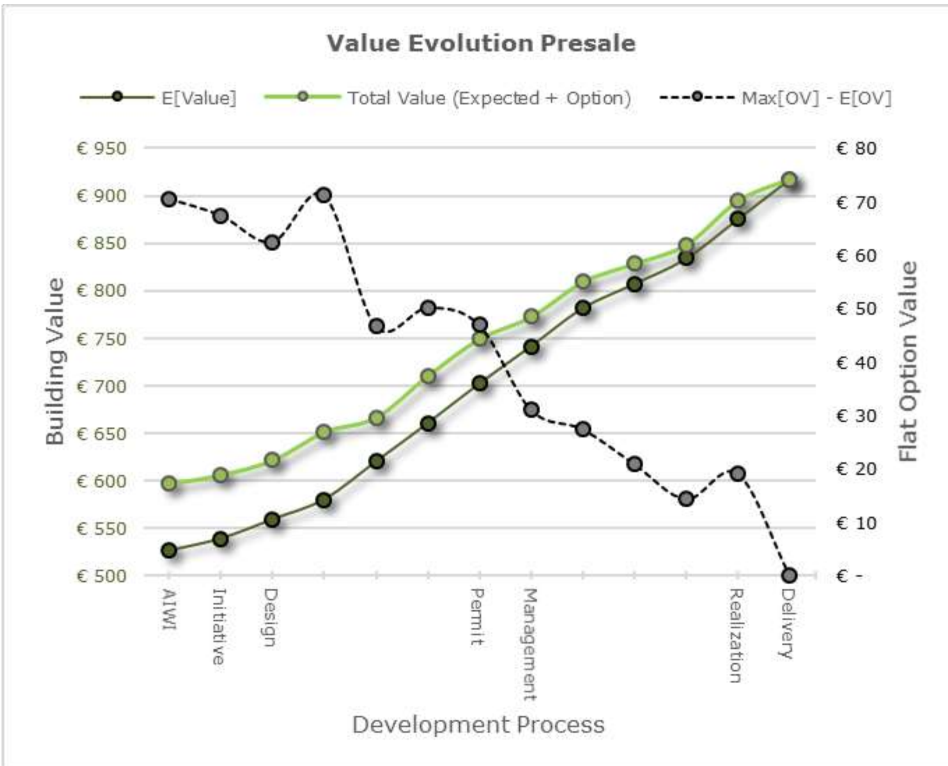


Figure 25 Value evolution and option value in presale (own ill.)

The value evolution of the presale scenario (frozen) shows an interesting change in comparison to the traditional process. It becomes apparent (but obvious) that a significant portion of the building value stems from the realization of the building itself. The main advantage is that, by dissecting the construction of the total development process, additional flexibility and additional value can be found. For the presale strategy, the option value is highest for the design phase and prior to the permit. In addition, the construction period shows another option value increase. A last remark has to be made that the management period (which is actually the presale period in this strategy) is fairly stable.

6.3.5 Presale (Set By Risk)

The presale process, set by risk shows that acquisition moments do not change in comparison with the traditional process, except for the risk-averse developer (i.e. fee-developer) which might acquire the building prior to realization.

The value evolution of pre-sale is interesting, but needs more research. Because the optionality remains open for the construction process, the total value of the project remains high. This indicates that the main contribution of value is in the realization of the project.

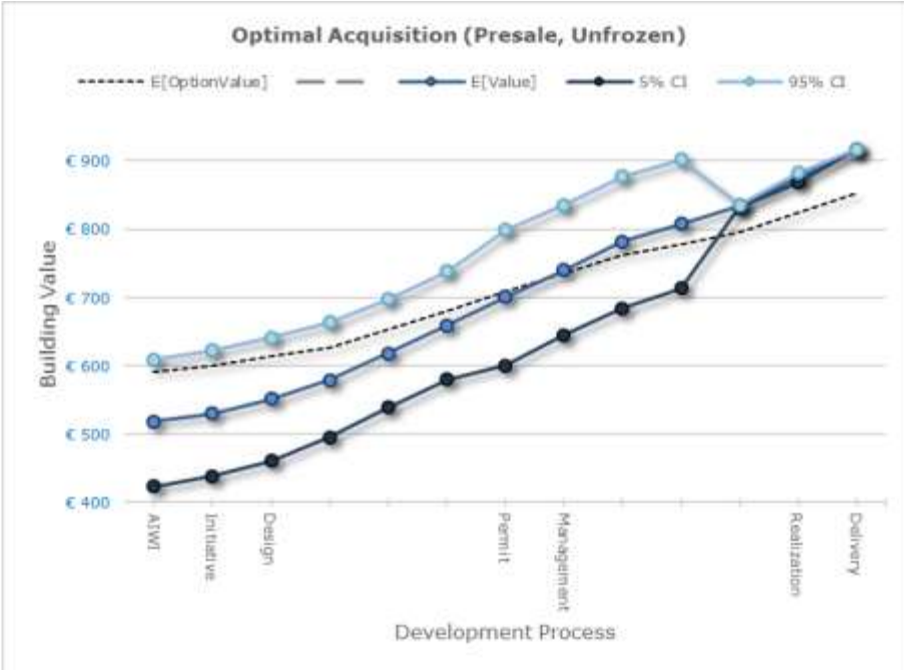


Figure 26 Optimal acquisition presale process, unfrozen (own ill.)

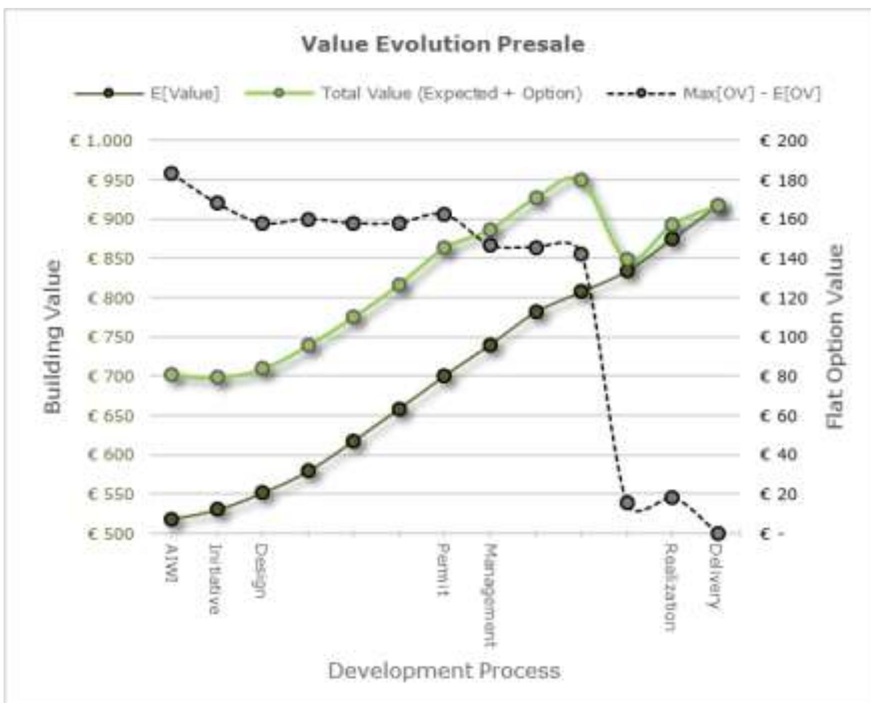


Figure 27 Value evolution presale, set by risk (own il..)

6.3.6 Presale (Bad Market)

Considering the optimal acquisition, a bad market does not influence the optimal acquisition moment.

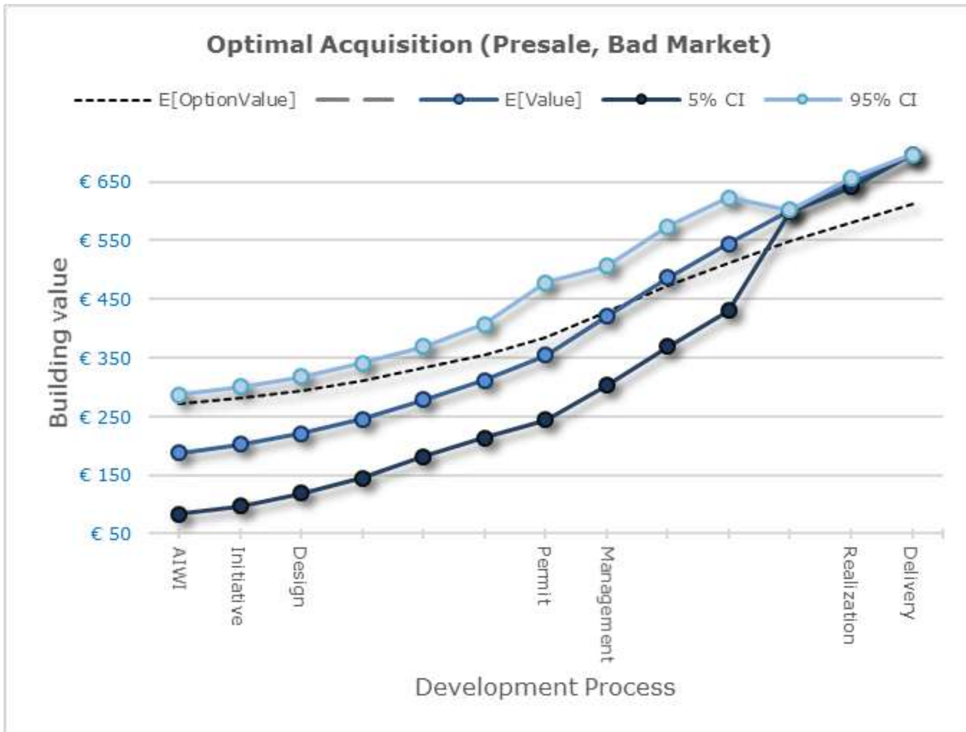


Figure 28 Optimal acquisition with presale and bad market (own ill.)

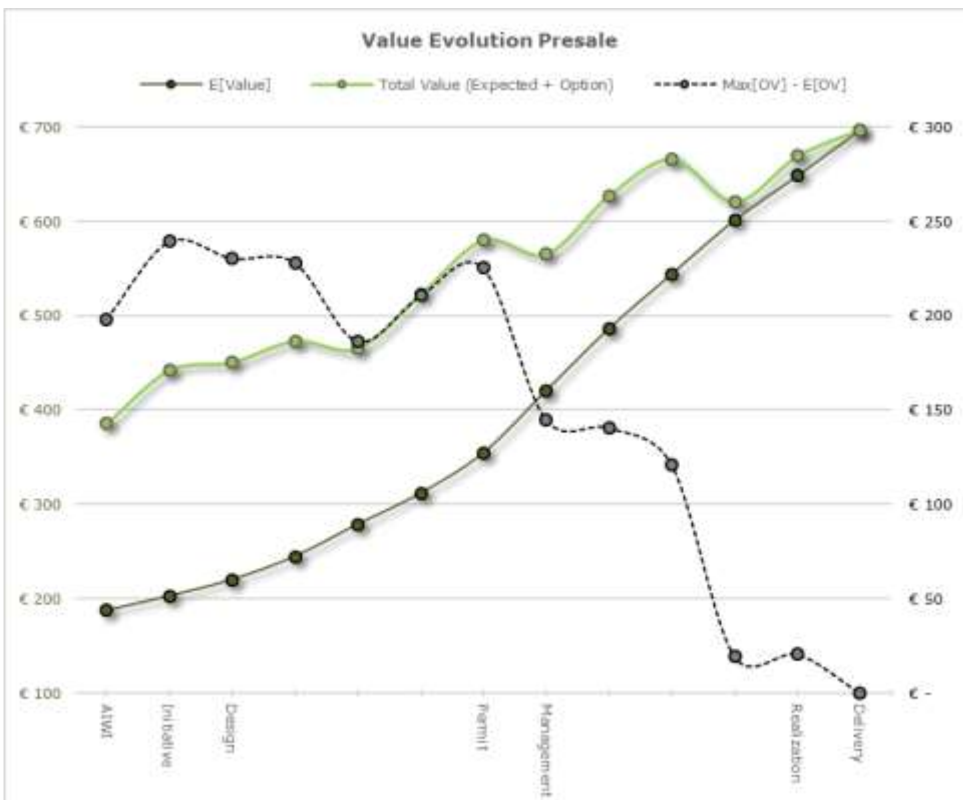


Figure 29 Value evolution presale, bad market (own ill.)

Considering the value evolution of a presale, in a bad market, primarily the option value evolution is interesting (see Figure 29). The option value evolution shows the same progression similar to a traditional process, but remains higher up until realization commences. There are two main points where the developer can contribute most value, being design and prior to preselling the project.

6.3.7 Conclusion

Analysis of the strategies has led to the following conclusions:

- The expected value of the option is a more robust way to value vacant real estate.
- The optimal acquisition moments under different circumstances and for different risk-attitudes can be found.
- The additional option value found through ROA shows where developers can add value.
- Excluding exogenous variables, value can be added in the design process, prior to construction and the sales process.
- Including exogenous variables, option value is highest AIWI, suggesting that market timing and variables not under influence of the developer primarily influence the option value.
- This is supported by the change in option valuation when exogenous variables are introduced, in that the option valuation evolution tends to be a flat line, rather than creating peaks. This would suggest that, when exposed to variables outside of the developer's control, the impact of the actions of the developer are primarily value-stabilization, rather than value-generating.
- By dissecting the realization of the total development process, interesting strategic considerations can be found. For example, postponing the construction or optimizing the construction before initiation.
- In bad markets, the pre-sale strategy provides a significant advantage in that it captures value sooner, and dissection of the construction period.
- In bad markets, the option value is highest, indicating that the effort needed by developers is highest. This can explain why developers are unwilling to develop in bad markets, as it requires more effort for less results.

6.4 Optimization

The optimization process is done by the Monte Carlo Crystall Ball plugin and consists of 2500 simulations of 5000 iterations each. The iterations are limited in comparison to the analysis of strategies in to speed up the process. It is advised by Crystall Ball to at least run 2000 iterations in simulations, 5000 should therefore be enough.

The optimization is run for a safe investment. Suppose a developer has some knowledge of a building and what risks he may face. In addition, he has some knowledge about the market and the conditions in which the development will take place. He wants to know which approach is best for the project from an option perspective and propose the option value and specific conditions to the building owner.

This can be denoted for optimization as the follows:

Objective: Maximizing UoR
Constraint: OV – ABV > 0

Where the maximization of units of risk means the reduction of risk. The constraint OV – ABV > 0 indicates that sufficient risk must be left in the project. An increase of units of risk leads to a reduced OV-ABV which can go negative. The objective and the constraint therefore try to find an optimum.

For each scenario the top 3 solutions will be examined in order to find the best logical solution. That is, the model assumes that the environmental permit can be approved without a finalized design. Because this is infeasible, the best 3 solutions will be analyzed for their applicability. The best solution (from the analysis) is highlighted green.

6.4.1 Frozen

The risky investment simulates the process where the developer wants to have the most control over the project but still wants to remain certain of his investment decision.

#	UoR	R1	R2	R3	R4	R5	R6	R7	ROI	Med(Good)	Med(Bad)	Med(OV)	Med(ABV)	Diff.
1	4.5	1	1	0.5	1	0	0	1	7.51%	€915,514	€172,045	€716	€714	€2
2	4.0	1	0.5	0.5	1	0.5	0.5	0	8.57%	€1,022,095	€177,994	€718	€719	(€1)
3	3.5	1	0.5	0	0	0.5	1	0	8.43%	€1,006,,206	€160,972	€691	€676	€15

Table 17 Safe investment - frozen, green indicates best solution by analysis.

The ranked 1 solution by optimization is the most realistic scenario, where the building is acquired and preparations are made for the presale. The difference between option value and adjusted building value is low indicating that under these conditions, the building is optimally acquired. The ROI is however less than the other scenarios. Scenario 2 seems most unrealistic as the design is not finalized but it suggest that acquisition should occur when the environmental permit is approved. These two situations contradict each other. Nevertheless, it is the best scenario based on the result. The third scenario is more risky and indicates that asbestos risk should be excluded. The total scenario is not odd, a preliminary design on a prospective building with a prospective investor and a partnering constructor who is willing to take on part of the risk. It also has the best remaining option value (€15/m^2) indicating that a lot of value can be created by good management. On basis of this analysis the first scenario suits the hardcore turn-key developer most and the last scenario fits best with the acquire-construct developer. Overall, the first scenario is best based on the real options analysis and feasibility.

6.4.2 Unfrozen

In the unfrozen scenario the MDVars are unfrozen offsetting the effects of the risk under control of the developer on the project. The same objective and constraints are set.

#	UoR	R1	R2	R3	R4	R5	R6	R7	ROI	Med(Good)	Med(Bad)	Med(OV)	Med(ABV)	Diff.
1	4.5	1	0.5	0	1	0.5	0.5	1	7.66%	€ 913,760	€180,511	€ 716	€ 720	(€4)
2	3.5	1	1	0	0	0	0.5	1	7.46%	€ 889,082	€154,940	€ 674	€ 659	€15
3	3	0	0.5	0	1	0	0.5	1	7.50%	€ 893,985	€158,202	€ 674	€ 665	€9

Table 18 Risky investment - unfrozen, green indicates best solution by analysis.

When the variables are unfrozen the optimization process finds less optimal solutions from an option point of view. The overall return on investment has decreased except for the best solution. The difference in option value has not increased for the second solution. In this case 3.5 units of risks are mitigated and a positive option value €15. The top solution has a negative option value but is deemed infeasible. On basis of the results the best strategy is the 2nd solution where the proposed solution is realistic and yields a similar ROI than the other two proposed solutions. This strategy resembles a fee-developer who will transform a building commissioned by an investor with the agreement that letting and pre-sale risk will be taken on by the investor.

6.4.3 Conclusion

Although only two optimizations are run, the conclusion can be made that with some information about the market, development and the object in question, an indication can be given about the conditions in which the conversion is feasible from a real option perspective.

6.5 Valuing Vacant Properties

The main research question of this thesis is whether real option valuation methods can accurately value vacant real estate for its potential future use, in this case the conversion to residential housing. In order to test this, the Airport Plaza case, Haarlemmermeer, will be used. This case was valued in the "Valuation of Vacant Properties" (Schiltz, 2007)by multiple commercial appraisers and would thus give an indication if the proposed model can value vacant real estate for its potential to conversion of housing. The details regarding the case can be found below.

Location	Jupiterstraat, Hoofddorp
Zoning Plan	Residential use allowed
GFA	4.053 m^2
LFA	3.600 m^2
Form Factor	0.88
Parking Spaces	100
Construction Year	1988
Technical State	Deemed suitable for transformation and no extensive technical alterations have to be made reducing the possible transformation costs.
Original Date of Valuation	1st December 2005

Figure 30 Airport Plaza, Hoofddorp (Schiltz, 2007).

For the probable sale price at the date of valuation as the thesis was written, the current sale prices will be used. Considering the residential market went through a bust and is currently in an (upcoming) boom it is assumed that prices are approximately on the same level. Currently, dwellings of 80 m^2 in the city center are going for €225.000 ex transfer tax which is approximately €2800 per square meter. Applying a reasonable discount due to the location being 10 minutes from the city center the used value is €2500. The construction costs can be relatively low due to the good construction but remain in the medium levels of transformation due to the irregular shape. The windows are manually operable as can be seen on the picture also reducing the transformation costs. The risks of asbestos is quite high due to the construction year (1988). The form factor is extremely high for such an irregularly shaped building but will be used as the max. Interest rates in 2005 were around 2.5%. All other variables will be the same as in the base case.

Variable	Min	Base	Max
Sale Price	€2300	€2500	€2700
UFA/GFA	0.8	0.85	0.88
Construction Costs	€750	€800	€850
Asbestos	€10	€20	€40
Interest Rate	2.25%	2.5%	2.75%

Under the assumption that asbestos will be removed the median vacant (option) value of €187 / m^2 (€ 758.000 total value) is found if the zoning plan does not allow for residential use. In the case that the zoning plan allows for housing, a vacant (option) value of €554 / m^2.

Method	Conditions	Per square meter	Total
JacuzziTool	Residential use prohibited *Asbestos removed.*	€187/ m^2	€758.000
JacuzziTool	Building Value under risk *Asbestos removed.*	€ 24 / m^2	€100.000
JacuzziTool	Residential use allowed *Asbestos removed.*	€554 / m^2	€2.186.000
JacuzziTool	Building value under risk *Asbestos removed*	€488/ m^2	€1.977.864
Appraisers	Vacant	€1.121 / m^2	€4.535.000 (mean)
Difference		**€ 567 / m^2**	**€2.359.000**

Although the difference is still significant the option value of the building without zoning plan resembles a better value than the building under all risk (which was traditional). In addition, the building was valued in the middle of the economic boom thus the appraisers were likely to overestimate, than underestimate the office building. This case study helps to illustrate the difference between the option values of a building, which takes into account the possibility of a zoning plan change, hence increasing the value instead of valuing it at the status quo. Moreover, it is an explanation of the acquisition of buildings by developers which were initially not allowed for residential use in the zoning plan but still offered an above market level price. Hence indicating that the developer was more knowledgeable than the building owner. This information asymmetry is easily exploited and can easily distort market valuation.

6.6 Conclusion

The incorporation of the option valuation framework can provide interesting insights in how developers add value to the process of development and under what conditions it is optimal to acquire the building. The gained insight can be used in a risk-profit sharing agreement where the building might be acquired at a certain option value but the building owner is accountable for some of the risk that may or may not occur.

By incorporating the FPOM framework in the BKM and a feasibility analysis, the option value of any project can be known instantaneously and can thus be employed for project selection. As a general rule, the higher the option value, the higher the risk, but accompanied with more upside potential if managed right. The assumption that the option holder actively increases the value of the project, or alternatively can abandon the project, is made within the real options framework and should not be forgotten.

To find the optimal conditions of conversion projects, two case studies which represent two different processes common in real estate development were analyzed: being the traditional process and the upfront sale to investor process.

Under normal conditions in a traditional process, the optimal time to acquire the building is when the environmental permit has been granted or just before the environmental permit has been granted. In bad conditions, the optimal time to acquire the building is when the construction risk has been accounted for. For an upfront sale to investor in a bad market, the presale or pre-letting has to be taken care of before acquisition can take place. In normal conditions, neighborhood and politics have to approve the conversion before acquisition occurs. It should be noted that these are conditions, and that although the value accruement has been set out over time, these conditions can be met at any time if realistic or within any kind of agreement.

In addition, an optimization was conducted on the base case in order to find the ideal solution under uncertainty. The top 3 solutions were analyzed and the most logical and realistic strategy was selected. Not all proposed solutions are realistic and they were rejected. The main caveat of the optimization process is that it does not acknowledge the non-linearity of real estate development. For example, an environmental permit cannot be approved without a final design. The aim is however not to propose the best realistic strategy, but the optimal conditions under which the building can be acquired and at what price. The optimization shows this by providing solutions of how to approach a project under uncertainty. It provides guidelines for the ideal circumstances when market, development and building risks are only partly known. These can be used for negotiation purposes, strategy implications and project selection.

The last part of the results was the valuation of a vacant property. The choice for this particular property was made because 6 appraisers made a valuation of the vacant property. The property is valued with and without a zoning plan change. Without a zoning plan change, the option valuation technique still finds a probable value of the vacant property where the traditional valuation method does not, also here the rule applies that this value does not provide instant profit, but indicates the possibility. The valuation with zoning plan change is lower than the proposed value by the appraisers but as this was based on the situation of 2005 this might be overvalued.

Part IV Conclusion and Discussion

7 Conclusion

This research aimed to value vacant real estate which can be converted to residential units. Although the research was demarcated to this particular development type and to the optimal moment of acquisition in particular, the results shed light on the decision-making of developers in general. This thesis aims to answer the main research question:

*Can **real option valuation techniques** in combination with **the Bathtubmodel** find the **value of vacant transformable real estate** under the assumption of the **limited choice** of **consolidation or immediate development?***

In order to answer the main research question four sub-questions were composed which will be answered before the main research question is answered:

1. What is the main role of the developer in the real estate development process?
2. How is vacant real estate valued in practice and what are the (dis)advantages?
3. What are real options and how can they be applied in the valuation of real estate redevelopment?

7.1 The Developer

In this section the following sub-question will be answered:

"What is the main role of the developer in the real estate development process?"

The role of a developer is broad. The main task of a developer is to obtain and retain assurance about six (6) main aspects of the development which span over five (5) phases as to secure a reasonable profit at project completion. In order to cope with these uncertainties the developer has several methods of approach (risk mitigation measures). The role of a developer is multi-disciplinary role encompassing design, financial, legal, technical and political aspects which are to be managed separately but influence each other throughout the process, non-linearity. Although literature is mainly focused on the mitigation of risk, the opportunities which developers capitalize are of equal importance. In some situations, aspects initially perceived as opportunities can eventually become risks. In these extreme complex and uncertain circumstances the developer attempts to make the decision whether to accept or reject a certain project, which essentially is an irreversible decision under uncertainty and manifests itself in the acquisition of land or vacant properties often paired with high investment costs. Even after thorough risk analysis has been made, risks and or opportunities (not identified in advance) which might occur after the irreversible decision has been made can alter the outcome of the project. Although this is well-known under academics and even more so under practitioners, simulating this is extremely difficult. Still, in this research, the emphasis was placed upon this decision-making under uncertainty. The answer to this sub-question is as follows:

"The main role of a developer in the real estate development process is to obtain and maintain assurance about the broad range of interrelated multi-disciplinary aspects spanning over multiple phases of a project in order to justify the irreversible decision of project commitment under uncertainty which manifests itself in the acquisition of real estate, ultimately to receive a reasonable profit at project completion".

A part of this answer is also the main focus of this research, "the irreversible decision of project commitment under uncertainty […] acquisition of real estate [vacant property]".

The valuation of vacant properties is problematic. Not only is the valuation a function of subjective input and uncertainty of the developer, also the moment of disposal by the building owner has significant influence on the value – primarily due to reduced uncertainty which is even more so in case of transformation. This leads to the second sub-question.

7.2 Valuation of Vacant Properties

The second sub-question focusses on a very actual and relevant problem in the valuation practice, the valuation of vacant real estate:

"How is vacant real estate valued in practice and what are the main (dis)advantages?"

In this research the available valuation methods are examined for their applicability in the valuation of the conversion of (structurally) vacant commercial real estate. The valuation methods all have their uses, although primarily limited from a specific perspective (e.g. investor or developer) only three seem to take into account the depreciation of value and appreciation of value over time through redevelopment. These are the vacant possession valuation method, the discounted cash flow valuation and bathtub model. The vacant possession valuation method is designed to measure the influence of lease expiry dates on the current market value of the commercial property. It is limited in the sense that it is focused on the building owner and under the assumption of a currently fully let building. The discounted cash flow model approaches the valuation problem from the perspective of the prospective investor by simulating the future use and discounting it back to today in order to find the current residual value. The last model, the bathtub model is focused on the value appreciation which occurs through the development process. A limitation is the assumption that several factors are known with certainty upon which the residual value under all risk can be determined. An interesting element of this last method however is the acknowledgement of value accruement over time during the development process. It acknowledges explicitly that the future state of the development process is more valuable (assuming this is known with certainty). This is of importance for both the developer as the building owner of structurally vacant real estate. For both parties, the moment of acquisition (and respectively disposition) is of importance. The developer, as discussed in sub-question 1 benefits from additional certainty about the several uncertain aspects of development, while the building owner receives additional benefit in the form a higher disposal price. At any moment during the development process, disregarding the strategic approach, the decision-maker might wonder whether significant uncertainty has been reduced or obtaining more information is beneficial. Traditional valuation methods cannot determine the actual value of the project because they only value the current situation (which results in a residual value) and do not acknowledge mutually exclusive investments. This is the main caveat of traditional valuation methodologies as it does not take into account the future possibilities and does not assign a value to it. This implicitly also means that the actual calculation of residual value remains a black box. The second sub-question is therefore answered as follows:

"Although almost all available valuation methods provide some way to value vacant real estate properly if applied correctly, they do not explicitly account for all mutually exclusive investments (such as waiting for more information), future possibilities, thereby potentially undervaluing the investment possibility."

Or in other words, the building with an environmental permit is worth more than a building without which is the same as the value of a building with a tenant or without a tenant. The traditional methods do not provide a way to value this future possibility without explicitly doing so.

7.3 Real Options

The third sub-question of this research focusses on the option to redevelop and serves as an introduction to the world of real options:

"What are real options and how can they be applied in the valuation of real estate redevelopment?"

Real options enable the appraiser or decision-maker to value the option to choose. Real options can be used as an arguably superior valuation tool or as a strategic tool. The former focusses on reactive management, enabling or acknowledging options on projects such as the option to defer a project to next year when conditions are more favorable. The latter focusses on using the option valuation framework to aid strategic decision-making, purposely implementing options in projects or to aid decision-making under uncertainty. In addition, it is acknowledged that when the project itself is an option (i.e. before the irreversible investment is made) the option holder can influence the option value to push it in-the-money (i.e. profitable project). This is the role of the developer by decreasing uncertainty, increasing potential profit and reducing potential costs (risks and opportunities). This research employed both the valuation and strategic side of real options thinking. Valuation occurs through the framework where for each individual step in the development process, the option value of the next step and the remainder of the project can be found including the latent value. Strategically in that it identifies the optimal moment to invest (i.e. acquire the building), which changes under different strategies and under different circumstances. Although no answer is given which strategy is superior to the other, the decision-maker himself should determine which strategy fits the project better. There are several ways to value real options. In prior research often the security option pricing methods were used which rely on a determination of volatility. The development process however is so specific, that subjective estimates by experts and decision-makers in form of a scenario analysis are better in terms of tractability. Therefore, the choice was made to employ the fuzzy pay-off method which enables the decision-maker to derive the option value based on only these three scenarios. This is a significant advantage to "older" option valuation methods as the composition of three scenarios is already often done in practice. The initial scenarios can be created through the bathtub model and incorporation of Monte Carlo extends this analysis.

The answer to this sub-question is as follows:

“Real options are a tool to find the opportunity value in investments under the assumption that the (future) option holder will pursue these opportunities in order to capitalize this value.’

7.4 Answering Main Research Question

The previously three sub-questions lead to the main research question of this research:

*Can **real option valuation techniques** find the **value of vacant transformable real estate** under the assumption of the **limited choice** of **consolidation or immediate development?***

In which “transformable” was defined as (structurally) vacant real estate which can be transformed to residential units now or in the future. To answer the question briefly. Yes it can.

In order to value the vacant building directly an expected outcome must be given. This is problematic in real estate development because the development process itself is extremely uncertain. As a result, in order to value the building, specific incremental value steps had to be determined. The bathtub model provided, although in a limited way, a mean to do so. With this incorporation, the latent value of the vacant real estate can be derived at any moment in the development process.

On the analysis of two approaches of a development process, the traditional and upfront sale process, multiple situations with ideal conditions were established. These optimal conditions serve as a guideline for strategy selection and negotiation, rather than being the optimal solution to the problem. Real options therefore resemble a valuation for opportunities, rather than just another feasibility analysis and should also be treated as such.

This is also exemplified in the Airport Plaza case, where the assumption was made that the zoning plan prohibited residential use of a vacant building. While a traditional valuation method would assign no value, or even negative value to the building, the real option value was around the going market level for vacant properties. This does not imply that acquiring such a building at the proposed price would grant instant profit, but rather that there is a possibility the value of the building is that high (relatively). The user of the real option technique should always be aware that real option value accrues from the actions of the real option holder. This is different than a financial option, where the option may or may not become valuable over time.

More importantly, the results suggest that option valuation techniques can provide insight and aid in the decision-making process of developers and support that what is described in literature and occurs in practice also referred to as “gut-feeling” (*onderbuikgevoel*). The “GO” decision is probably one of the hardest part of real estate development as the developer is committed to the project when he acquires the building. Real options assign value to potential profit, and therefore the task of the user is to find and pursue that what drives the value of the option.

8 Recommendation & Reflection

8.1 Recommendations

The recommendations will be divided in recommendations for future research and for practice.

Recommendations for future research:

- **Limitation to consolidation or conversion to residential:** the research is limited to consolidation (getting more certainty) or conversion to residential units. A vacant office building has multiple probable future uses and these different options influence each other (i.e. more mutually exclusive alternatives). However, when multiple options are considered the determination of the option value is considerably harder. In practice, the ideal solution is often quickly assumed and feasibility analyses will only be made for that future use, while other uses might be more beneficial in the future.
- **Influence of competition:** the research assumes that the developer has the exclusive right for exercise implying that there is no competition in the market and the resulting bid from the real option analysis will probably be accepted. In reality however, multiple developers could be bidding on the building at the same time. Competition negatively influences the option valuation due to fear of preemption, hence leading to earlier acquisition and an overvalued price. The research covering this is termed game theory and the integration of option valuation and game theory has been well established in research.
- **Identification of opportunities:** as seen in the results, at certain moments the potential upside becomes larger than the potential downside. Identifying and quantifying these opportunities in a more coherent and precise manner is desirable in order to facilitate conversions.

Recommendations for practice:

- **Institutionalizing of real estate practice,** first and foremost the need for transparency and institutionalization in real estate is very much desirable. If project results can be shared and risks can be more correctly identified and quantified, this can improve decision-making substantially. Vacant real estate is not solely a problem for the building owner but also an issue for society. If the multitude of distressed loans will default, banks can be sent back into recession. With collaboration, transparency and proper identification and quantification of risks, the paid price for a building can be higher, which leads to more transformation, less equity at risk and is beneficial for the building owner and society.
- **Collaboration:** vacant buildings are not a problem, but an opportunity if managed correctly. This requires collaboration between the building owner and the developer and creativity in how to approach the problem of conversion.
- **Employ real options (thinking):** the real power of real options does not lie within the actual valuation of the option itself, but the enforcement of thinking about options. Comparing alternatives (mutually exclusive investments) prior to accepting the most profitable or obvious solution can lead to improved results, qualitatively and quantitatively. With the real option valuation framework, infeasible projects can become feasible and can provide guidelines for the optimal conditions of investment. In recent years, simpler option valuation methods have been designed and proven to be working, but alas never adopted.

8.2 Reflection

This research on the application of real options in the valuation of vacant office valuation has led to guiding model that can be employed to find ideal strategies for uncertain real estate developments. The product is a result of literature research and a base case model which has been analyzed. Additional input from my internship and conversations with experts was also incorporated in the end result. This reflection looks back on the process, the methodology and the results.

After reading about real options in the Design & Construction Management book I instantaneously decided I wanted to graduate on the topic of real options. At the start of my graduation process, vacancy and in particular transformation was high on the agenda. Therefore the decision to apply real options in the transformation process was made. Although research regarding the problem (vacancy) was abundant, the literature about real options was even more so. This led me to considerably lose focus on a particular problem and saw applications of real options everywhere. In addition, a considerable amount of the real options literature demands (quite high) mathematical knowledge, which I lacked due to my pre-education. The ambition to employ the state-of-the-art real option methodologies led me to an infeasible desire to learn partial differential equations, other (random) skills and an extensive literature research which were not beneficial for my thesis, nor for the duration of my graduation period. In this respect, I should have made more definitive choices in an earlier stage of my research based on my current knowledge and skills and broaden them with my research. In addition, during this stage my research question and general focus of the research (literally) changed by week. This has ultimately led to a reduction of depth and extensiveness of my research. The challenge of exploring unmined territory was however interesting, but led to problems in finding guidance from my coordinators.

Although some interviews were conducted, I did not include them in my research as those were primarily on the topic of real options. As the focus of my research was not on researching real options or their applicability in general themselves, but to solve a problem with real options, these are excluded. Therefore, it might had been better if I either had structured the interviews, or completely excluded them. This also did not help in the demarcation of my research, nor a sharper clarification of the problem at hand. When I started my internship at Local my research was monitored and led me to meet several people with whom I could discuss my graduation. This has significantly sped up my graduation process, led to valuable insights and especially led to a sharper notion of the role of the developer.

On that notion, the results from my research indicate the power of real options, but somewhat superficial and is based on only two (commonly) applied strategies which are further analyzed. The limitations of the model could have been solved, but due to time restrictions were decided to be left to future research. For which I do not exclude myself. Overall, the research could have benefitted from using more research backed assumptions, rather than subjective input. Here in lies an interesting contradiction in that developers often do not trade information, nor do averages or general data apply to all projects due to their uniqueness, thus the quality of this data can be put into question. Another question which might arise is whether developers already unconsciously employ real options thinking in that they determine the potential of projects on the ability to influence the risks and opportunities within. For those developers, keep going. For others, start thinking about your options.

"Hij verdient een hoop geld in de bouw, zo'n projectontwikkelaar,
die ouwe rotzooi verandert in nieuwe rotzooi, maar wel duurder"

Simon Carmiggelt, schrijver

9 Literature

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Project Information & Uninfluencable Uncertainty

Option Value Calculator		**Building Information**			
Project Name	Airport Plaza	**GFA**			5,500
Address	Jupiterstraat, Hoofddorp	**UFA**			4,200
Version	Vacant Value	**End Development Phase**			03.04.17
Date	03.10.16	**End Construction**			03.06.18
Assumptions Development		**Min**	**Base**	**Max**	
Asbestos Removal Costs		0	10	25	Direct
Demolition Costs		15	25	30	Direct
Transformation Costs		800	900	1000	Direct
Additional Costs			26%		
Construction Period		12 months	14 months	16 months	14 months
Development Period		5 months	6 months	7 months	6 months

Program					
No. Dwellings	70.0		Correlation Demolishing / Constructic		0.5
GFA	78.2		Correlation Construction / Sale Price		0.70
Average UFA	60.0				
Assumptions Market		**Min**	**Base**	**Max**	
Current Sale Price		€ 2,900	€ 3,000	€ 3,100	Direct
UFA/GFA		0.75	0.77	0.78	0.77
Interest Rate		0.50%	0.75%	1.00%	Direct
Indexation		1.75%	2.00%	2.50%	2.07%

Costs and Revenue

COSTS					
Building Costs	**m2 GFA**	**Price**	**Total**	**Index**	**Costs / m2 GFA**
				1.03	
Asbestos	5500 m2	€ 11	€ 62,188	€ 64,345	€ 12
Demolishing	5500 m2	€ 24	€ 130,131	€ 134,645	€ 24
Transformation Costs	5500 m2	€ 900	€ 4,950,000	€ 5,121,699	€ 931
Total Building Costs			**€ 5,142,320**	**€ 5,320,689**	**€ 967**
Risk Mitigation			€ (1,084,197)	€ (1,121,804)	€ (204)
Construction Costs - Risk			€ 4,058,122	€ 4,198,885	€ 763
Additional Costs	26%	€ 5,142,320	€ 1,337,003	€ 1,383,379	€ 252
SUBTOTAL COSTS				**€ 5,582,264**	**1015**
Construction Loan	0.75%	€ 5,582,264	14 months	**€ 48,845**	**9**
Subtotal Costs				**€ 5,631,109**	**1024**
Land Costs	**€ 5,500**	**€ 739**	**€ 4,062,673**	**€ 4,203,594**	**€ 764**
Transfer Tax (Office / Land)	6%	€ 4,062,673	€ 243,760	€ 252,216	€ 44
VAT	21%	€ 5,582,264	€ 1,172,275	€ 1,172,275	€ 213
Total Costs incl. VAT				**€ 11,259,194**	**€ 2,047**

REVENUE						
	No. Dwellings	**m2 GFA**	**Price / UFA**	**Revenue Dwelling**	**Revenue**	**Index**
Sale						1.03
Dwellings	70	60.0	3000	€ 180,000	€ 12,600,000	€ 13,037,051
Tax Dwellings	2%			€ 12,600,000	€ (252,000)	€ (260,741)
Total Revenue					**€ 12,348,000**	**€ 12,776,310**
Risk Premium						**€ (1,311,013)**
Revenue - Risk Premium						**€ 11,465,297**
Expected Result All Risks Avoided		**13.23%**	**€ 276**			**€ 1,517,117**
Expected Result All Risks Occur		**1.67%**	**€ 37**			**€ 206,104**

Figure 31 Screenshot of Jacuzzi Model, Input Tab

Project Info			
Project Information			
Project Name	Base Case		*Room for your notes.*
Address	Base Case		
GFA	5500		
UFA	4200		

Option Calculation	All Risk	Calculate	ROV Calculation	Profit / Risk	No Risk	Option Reduced	Option Value Building	
Residual Land Value Calculation								
Transformation Value	€ 11,162,756	€ -	€ 477	€ 1,613,554	€ 12,776,310	€ 11,162,756		
Transfer Tax Office	€ (267,437)	€ -	€ 477	€ (165,591)	€ (433,028)	€ (267,437)		
Transformation Costs	€ (5,320,689)	€ -	€ 951	€ 1,084,197	€ (4,236,492)	€ (5,320,689)		
Additional Costs	€ (1,383,379)	€ -	€ -	€ -	€ (1,383,379)	€ (1,383,379)		
VAT	€ (1,407,854)	€ -	€ 473	€ 227,681	€ (1,180,172.92)	€ (1,407,854)		
Net Residual Worth	€ 2,783,396			€ 2,759,843	€ 5,543,239	€ 2,783,396		
Transfer Tax Office	€ (157,551)		€ 556		€ (313,768)	€ (157,551)		
Residual Value	**€ 2,625,845**	€ -	#DIV/0!		**€ 5,229,470**	**€ 2,625,845**	€ 3,059,783	**OV - OR**
Residual Value / m2 GFA	€ 477.43				€ 951	€ 477.43	€ 556	€ 79

Influencable Uncertainty									
Exclude Z&T? (1=No,0=Yes)							Boundary to Invest		**1.17**
1									
No.	**Uncertainty**	**Percentage**	**Mean**	**Mean (Ass)**	**SD**	**Effects**	**Per square Meter**	**Absolute value**	**DCs**
8	Tax Ruling	5%	5%			Costs	€ 116	€ 638,815.51	0
7	Letting & Presale	2%	2%	2%	0.4%	Revenue	€ 73	€ 403,388.62	0
6	Sale	4%	3%	3%	0.6%	Revenue	€ 110	€ 605,083	0
5	Construction	10%	8%	8%	1.6%	Costs	€ 95	€ 520,316	0
4b	Environmental Permit	5%	4%	4%	0.8%	Costs	€ 47	€ 260,158	0
4a	Zoning Plan Change	25%	25%			Optional	€ 750	€ 3,150,000	0
3	Neighborhood & Politics	4%	3%	3%	0.6%	Revenue	€ 110	€ 605,083	0
2	Design	5%	4%	4%	0.8%	Costs	€ 44	€ 241,534	0
1	Asbestos & Land Contamination					Residual Costs	€ 11	€ 62,188	0
							Total Risk Capital / m2	Total Risk Capital	
	Total	**29%**					€ 1,357	€ 6,486,567	0

Figure 32 Screenshot of Jacuzzi Model, Option Valuation Tab

	AIWI	Initiative	Design				Permit	Realization	Delivery	Management			
Traditioneel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Sale (Consumer)	0	0	0	0	0	0	0	0	0	0	0	0,5	1
Sale (Investor)	0	0	0	0	0	0	0	0	0	0,5	1	1	1
Construction	0	0	0	0	0	0	0	0,5	1	1	1	1	1
Environmental Permit	0	0	0	0	0	0	1	1	1	1	1	1	1
Neighborhood & Politics	0	0	0	0	0,5	1	1	1	1	1	1	1	1
Design	0	0	0,5	1	1	1	1	1	1	1	1	1	1
Asbestos & Land Contamination	0	1	1	1	1	1	1	1	1	1	1	1	1
Traditional Frozen													
E[OptionValue]	**€ 591**	**€ 600**	**€ 613**	**€ 627**	**€ 654**	**€ 681**	**€ 709**	**€ 736**	**€ 764**	**€ 791**	**€ 817**	**€ 834**	**€ 852**
Min[Option]	**€ 503**	**€ 495**	**€ 480**	**€ 540**	**€ 572**	**€ 595**	**€ 610**	**€ 665**	**€ 691**	**€ 734**	**€ 770**	**€ 822**	**€ 852**
Max[Option]	**€ 662**	**€ 667**	**€ 676**	**€ 698**	**€ 701**	**€ 731**	**€ 756**	**€ 787**	**€ 809**	**€ 821**	**€ 840**	**€ 842**	**€ 852**
E[Value]	**€ 526**	**€ 539**	**€ 559**	**€ 580**	**€ 620**	**€ 660**	**€ 702**	**€ 743**	**€ 785**	**€ 825**	**€ 865**	**€ 891**	**€ 917**
5% CI	**€ 481**	**€ 494**	**€ 514**	**€ 536**	**€ 584**	**€ 625**	**€ 667**	**€ 708**	**€ 749**	**€ 803**	**€ 845**	**€ 886**	**€ 917**
95% CI	**€ 563**	**€ 576**	**€ 596**	**€ 618**	**€ 648**	**€ 689**	**€ 730**	**€ 773**	**€ 813**	**€ 841**	**€ 879**	**€ 895**	**€ 917**
Max[OV] - E[OV]	€ 71	€ 67	€ 62	€ 71	€ 47	€ 50	€ 47	€ 51	€ 45	€ 31	€ 23	€ 8	€ 0
Total Value (Expected + Option)	€ 597	€ 606	€ 622	€ 651	€ 667	€ 710	€ 749	€ 794	€ 830	€ 856	€ 888	€ 898	€ 917
Traditional (By Risk)													
E[OptionValue]	**€ 584**	**€ 592**	**€ 606**	**€ 627**	**€ 652**	**€ 680**	**€ 707**	**€ 735**	**€ 764**	**€ 790**	**€ 816**	**€ 834**	**€ 852**
Min[Option]	**€ 408**	**€ 391**	**€ 405**	**€ 445**	**€ 493**	**€ 528**	**€ 571**	**€ 611**	**€ 693**	**€ 735**	**€ 765**	**€ 820**	**€ 852**
Max[Option]	**€ 767**	**€ 759**	**€ 764**	**€ 787**	**€ 810**	**€ 838**	**€ 807**	**€ 836**	**€ 812**	**€ 817**	**€ 840**	**€ 843**	**€ 852**
E[Value]	**€ 518**	**€ 530**	**€ 552**	**€ 579**	**€ 618**	**€ 659**	**€ 701**	**€ 742**	**€ 785**	**€ 824**	**€ 864**	**€ 890**	**€ 917**
5% CI	**€ 423**	**€ 439**	**€ 461**	**€ 495**	**€ 539**	**€ 580**	**€ 647**	**€ 688**	**€ 750**	**€ 804**	**€ 844**	**€ 885**	**€ 917**
95% CI	**€ 610**	**€ 622**	**€ 642**	**€ 664**	**€ 697**	**€ 738**	**€ 755**	**€ 795**	**€ 812**	**€ 840**	**€ 879**	**€ 895**	**€ 917**
Max[OV] - E[OV]	€ 183	€ 168	€ 158	€ 160	€ 158	€ 158	€ 100	€ 101	€ 49	€ 27	€ 24	€ 9	€ 0
Total Value (Expected + Option)	€ 701	€ 698	€ 709	€ 739	€ 776	€ 817	€ 801	€ 843	€ 834	€ 852	€ 888	€ 899	€ 917
Bad Market Traditional													
E[OptionValue]	**€ 271**	**€ 281**	**€ 293**	**€ 311**	**€ 334**	**€ 355**	**€ 386**	**€ 417**	**€ 450**	**€ 495**	**€ 540**	**€ 576**	**€ 613**
Min[Option]	**€ 76**	**€ 79**	**€ 83**	**€ 90**	**€ 111**	**€ 85**	**€ 193**	**€ 209**	**€ 305**	**€ 394**	**€ 445**	**€ 541**	**€ 613**
Max[Option]	**€ 469**	**€ 520**	**€ 523**	**€ 539**	**€ 520**	**€ 566**	**€ 611**	**€ 629**	**€ 532**	**€ 553**	**€ 586**	**€ 595**	**€ 613**
E[Value]	**€ 188**	**€ 203**	**€ 220**	**€ 245**	**€ 279**	**€ 312**	**€ 354**	**€ 403**	**€ 451**	**€ 518**	**€ 586**	**€ 640**	**€ 697**
5% CI	**€ 84**	**€ 97**	**€ 119**	**€ 144**	**€ 182**	**€ 213**	**€ 244**	**€ 293**	**€ 386**	**€ 474**	**€ 543**	**€ 630**	**€ 697**
95% CI	**€ 287**	**€ 300**	**€ 318**	**€ 341**	**€ 369**	**€ 407**	**€ 478**	**€ 525**	**€ 502**	**€ 551**	**€ 617**	**€ 649**	**€ 697**
Max[OV] - E[OV]	€ 198	€ 239	€ 230	€ 228	€ 186	€ 210	€ 225	€ 212	€ 83	€ 59	€ 46	€ 19	€ 0
Total Value (Expected + Option)	€ 386	€ 442	€ 451	€ 473	€ 465	€ 522	€ 580	€ 614	€ 533	€ 577	€ 632	€ 659	€ 697

Figure 33 Raw data, traditional process analysis.

	AIWI	Initiative	Design				Permit	Management				Realization	Delivery
Presale	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Sale (Consumer)	0	0	0	0	0	0	0	0	0	0,5	1	1	1
Sale (Investor)	0	0	0		0	0	0	0,5	1	1	1	1	1
Construction	0	0	0	0	0	0	0	0	0	0	0	0,5	1
Environmental Permit	0	0	0	0	0	0	1	0	1	1	1	1	1
Neighborhood & Politics	0	0	0	0	0,5	1	1	1	1	1	1	1	1
Design	0	0	0,5	1	1	1	1	1	1	1	1	1	1
Asbestos & Land Contamination	0	1	1	1	1	1	1	1	1	1	1	1	1
E[OptionValue]	**€ 591**	**€ 600**	**€ 613**	**€ 627**	**€ 654**	**€ 681**	**€ 709**	**€ 735**	**€ 762**	**€ 779**	**€ 796**	**€ 824**	**€ 852**
Min[Option]	**€ 503**	**€ 495**	**€ 480**	**€ 540**	**€ 572**	**€ 595**	**€ 610**	**€ 684**	**€ 717**	**€ 762**	**€ 789**	**€ 811**	**€ 852**
Max[Option]	**€ 662**	**€ 667**	**€ 676**	**€ 698**	**€ 701**	**€ 731**	**€ 756**	**€ 766**	**€ 789**	**€ 799**	**€ 810**	**€ 843**	**€ 852**
E[Value]	**€ 526**	**€ 539**	**€ 559**	**€ 580**	**€ 620**	**€ 660**	**€ 702**	**€ 741**	**€ 782**	**€ 807**	**€ 834**	**€ 875**	**€ 917**
5% CI	**€ 481**	**€ 494**	**€ 514**	**€ 536**	**€ 584**	**€ 625**	**€ 667**	**€ 720**	**€ 762**	**€ 803**	**€ 834**	**€ 869**	**€ 917**
95% CI	**€ 563**	**€ 576**	**€ 596**	**€ 618**	**€ 648**	**€ 689**	**€ 730**	**€ 758**	**€ 796**	**€ 811**	**€ 834**	**€ 883**	**€ 917**
Max[OV] - E[OV]	€ 71	€ 67	€ 62	€ 71	€ 47	€ 50	€ 47	€ 31	€ 27	€ 21	€ 14	€ 19	€ 0
Total Value (Expected + Option)	€ 597	€ 606	€ 622	€ 651	€ 667	€ 710	€ 749	€ 772	€ 809	€ 828	€ 848	€ 895	€ 917
Presale (By Risk)													
E[OptionValue]	**€ 584**	**€ 592**	**€ 606**	**€ 627**	**€ 652**	**€ 680**	**€ 708**	**€ 734**	**€ 762**	**€ 778**	**€ 795**	**€ 823**	**€ 852**
Min[Option]	**€ 408**	**€ 391**	**€ 405**	**€ 445**	**€ 493**	**€ 528**	**€ 537**	**€ 580**	**€ 610**	**€ 640**	**€ 787**	**€ 809**	**€ 852**
Max[Option]	**€ 767**	**€ 759**	**€ 764**	**€ 787**	**€ 810**	**€ 838**	**€ 870**	**€ 880**	**€ 908**	**€ 920**	**€ 811**	**€ 842**	**€ 852**
E[Value]	**€ 518**	**€ 530**	**€ 552**	**€ 579**	**€ 618**	**€ 659**	**€ 701**	**€ 740**	**€ 782**	**€ 807**	**€ 834**	**€ 875**	**€ 917**
5% CI	**€ 423**	**€ 439**	**€ 461**	**€ 495**	**€ 539**	**€ 580**	**€ 600**	**€ 645**	**€ 684**	**€ 714**	**€ 831**	**€ 868**	**€ 917**
95% CI	**€ 610**	**€ 622**	**€ 642**	**€ 664**	**€ 697**	**€ 738**	**€ 799**	**€ 835**	**€ 877**	**€ 902**	**€ 835**	**€ 882**	**€ 917**
Max[OV] - E[OV]	€ 183	€ 168	€ 158	€ 160	€ 158	€ 158	€ 162	€ 147	€ 145	€ 142	€ 15	€ 19	€ 0
Total Value (Expected + Option)	€ 701	€ 698	€ 709	€ 739	€ 776	€ 817	€ 863	€ 887	€ 927	€ 949	€ 849	€ 893	€ 917
Presale Bad Market													
E[OptionValue]	**€ 271**	**€ 281**	**€ 293**	**€ 311**	**€ 334**	**€ 355**	**€ 386**	**€ 429**	**€ 472**	**€ 511**	**€ 549**	**€ 581**	**€ 613**
Min[Option]	**€ 76**	**€ 79**	**€ 83**	**€ 90**	**€ 111**	**€ 85**	**€ 193**	**€ 178**	**€ 245**	**€ 342**	**€ 540**	**€ 566**	**€ 613**
Max[Option]	**€ 469**	**€ 520**	**€ 523**	**€ 539**	**€ 520**	**€ 566**	**€ 611**	**€ 574**	**€ 613**	**€ 632**	**€ 568**	**€ 601**	**€ 613**
E[Value]	**€ 188**	**€ 203**	**€ 220**	**€ 245**	**€ 279**	**€ 312**	**€ 354**	**€ 420**	**€ 486**	**€ 544**	**€ 601**	**€ 648**	**€ 697**
5% CI	**€ 84**	**€ 97**	**€ 119**	**€ 144**	**€ 182**	**€ 213**	**€ 244**	**€ 302**	**€ 369**	**€ 430**	**€ 599**	**€ 641**	**€ 697**
95% CI	**€ 287**	**€ 300**	**€ 318**	**€ 341**	**€ 369**	**€ 407**	**€ 478**	**€ 507**	**€ 573**	**€ 623**	**€ 602**	**€ 657**	**€ 697**
Max[OV] - E[OV]	€ 198	€ 239	€ 230	€ 228	€ 186	€ 210	€ 225	€ 145	€ 141	€ 121	€ 19	€ 21	€ 0
Total Value (Expected + Option)	€ 386	€ 442	€ 451	€ 473	€ 465	€ 522	€ 580	€ 565	€ 627	€ 665	€ 620	€ 669	€ 697

Figure 34 Raw data, presale process analysis.