

## The requirement for flexibility in capital budgeting

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**Abstract**

Capital investments are always long-term commitments of capital. When considering the undertaking of these projects, managers are faced with a high level of uncertainty. To better equip firms to respond to fluctuations in influencing factors, such as changes in demand and interest rate levels, capital budgeting needs to account for the value of flexibility options. Flexibility entails the alterations that can be conducted to the investment plan or when the initial capital outlay has already been done. It can contain altering the level of operations, choice of timing or even shutting down the project. In order to make the optimal capital budgeting decision, the value of a project needs to include flexibility into calculations. This paper examines the various forms and valuation of flexibility.

The importance of flexibility has been widely recognised, as the review of previous literature proves. Bringing external factors into the analysis is crucial, as they have a direct effect on the principle elements of traditional capital budgeting. One of these factors is the interest rate level, which is directly linked to the set hurdle rate, weighted average cost of capital (WACC). The WACC is used in capital budgeting as a discount rate. To further highlight the effect of interest rate fluctuations in capital budgeting, a sensitivity analysis has been conducted by altering the used hurdle rate. The chosen focus on this specific external influencer stems from the current environment of low rates. If the current situation induces prolonged assumptions of low interest rate levels, the eventual shift may expose projects to be unprofitable ex post.

The methods of valuing flexibility have been researched vastly, though rarely been put to practise. The main reason behind this is the complex nature of the methods. Also, flexibility is often viewed as an added expense or a burden to capital budgeting. The motivation behind this paper is to further demonstrate the true importance of flexibility options and to critically evaluate the applicability and precision of the presented valuation methods.

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**Keywords** capital budgeting, flexibility, real options, interest rates, uncertainty

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## 1. Introduction

In the current state of our world economy, boosting investments has long been viewed as an effective fixing method. By encouraging further capital commitments in order to create more available jobs and overall economic growth, increased investments are a positive development. Interest rate targeting by central banks is a way for monetary policy to encourage more investment through affordable loan capital (Roche et. al, 2015). However, at this point in time interest rates are at a record low and the environment is ever more turbulent. Globalisation and the fast development of information technology have resulted to shorter product life cycles, constantly changing consumer preferences and increasingly aggressive competition (Dreyer and Grønhaug, 2004).

Capital budgeting is a key function to evaluate investment profitability. The information provided by these calculations is then used as a basis for capital outlay decisions. The most common methods used in capital budgeting by US firms are the net present value (NPV) and internal rate of return (IRR) methods (Graham and Harvey, 2002). Both of these use a set hurdle rate, the weighted average cost of capital (WACC) in calculations and as a comparison to aid decision-making. The WACC is determined by utilising the risk-free rate, and is thus prone to distortion effects caused by the current zero-bound level interest rates in place. If we move on to the European markets, where the most common technique is the payback period (PB) method (Brounen et al. 2004), the interest rate level comes into play again through the discounted cashflows. The unusual state of the world economy affects decisions made by accounting departments, causing distortion due to false market effects (Roche et al. 2015). Traditional methods rely heavily on the WACC, which can easily be wrongly evaluated. If interest rate levels elevate unexpectedly, calculations may become invalid. However, as rates are expected to remain relatively low for some time still, shorter-term capital allocation projects are less prone to fluctuations in rate levels. Also, short-term cashflows can be forecasted more reliably. The situation is different in longer-term projects. As the time horizon of a project grows so does the uncertainty regarding its outcomes. Due especially to these recent developments, an increased level of flexibility in long-term investments is

desirable. To better understand the benefits of flexibility is therefore crucial to sustain competitive advantage.

This analysis focuses solely on illiquid investments made by private sector actors, such as production facilities or machinery. To define what is meant by flexibility, it is the range of options that the investment itself contains. It is not a one-sided concept, as it entails multiple options. At its simplest, it can be defined as flexibility in the breadth of capacity, operation level, production outputs, volume and timing (Dixit and Pindyck, 1994; Dreyer and Grønhaug, 2004). In long-term decision-making investments are vulnerable to changes and it might be desirable to be able to defer investment, alter the focus or even modify the overall direction or timing of a given project. Investments may have an abandonment option or possibilities for alteration in e.g. production facilities (Dixit and Pindyck, 1994). Also, real options, which are new project possibilities obtained by making the initial investment, are considered as a part of flexibility as they give room for modifications to the initial investment plan, should conditions change. Solely pushing for more investments without considering the effects and risks brought on by a longer time horizon is an ignorant move. It should be kept in mind that conditions might and will change in the scope of the investment period, as it grows to several decades. Markets are volatile and forecasting models always imperfect. Interest rates are traditionally considered to be more stable than revenues, which is why they are viewed as a constant in calculations, mostly focusing on altering cash flow scenarios (Alvarez and Koskela, 2006). In the current state of the world, this assumption is no longer valid in the long run. As a clarification, the cause of current interest rate levels will not be analysed, but it is a given factor within this thesis.

The factor of uncertainty in investment decisions is often disregarded (Chittenden and Derregia, 2015). The risk profile of long-term investments is generally higher than that of the short term, as the determination of cash flow forecasts becomes more difficult (Cornell, 1999). However, firms usually still only set a single hurdle rate to evaluate all investments, regardless of the time horizon. A survey in the Nordic countries discovered that 85,6% per cent of firms responded that their hurdle rates don't increase with the time scope of the investment. What is even more alarming is that some even used a lower rate for the longer term (Brunzell et al. 2013). These implications show that firms

are not at the moment fully aware of the requirements brought on by the increased uncertainty in our investment environment. Practise does not comply with general financial theory, suggesting that the longer span of future cash flows requires higher hurdle rates, as they are more uncertain (Mukherjee, 1991).

If we move on to the execution of the actual requirement, flexibility, room for improvement definitely exists. In order for firms to better maintain their market positioning and even exist in today's highly competitive business environment, they must acquire heightened levels of flexibility. This aids them to weather the movements of the turbulent environment (Dreyer and Grønhaug, 2004). Valuation of flexibility and real options obtained is complex, as it includes multiple levels and time horizons. However, it is now more important than ever for firms to focus their capital assets on investments with strong potential in order to ensure future success. Often the valuation models developed in order to count flexibility into calculations are not put to use due to their complicated and multi-level nature (Smit and Trigeorgis, 2006). This leads to misevaluation, as the true value of flexibility is not included, further leading to misevaluations and faulty decision-making in capital budgeting (Feinstein and Lander, 2002).

This thesis aims to pinpoint the need for added flexibility and the reasoning behind it. Short-sighted, traditional decision-making processes lack the ability to exhaust all possible options, making them inadequate to fit the current environment. The motivation behind this paper is to further demonstrate the importance of flexibility options, the benefits derived from their adoption into capital budgeting and to critically evaluate the presented methods of valuation. In order to achieve this, the paper will assess the validity of three key propositions:

1. Capital budgeting methods need to incorporate flexibility in order to correctly value investment opportunities
2. Flexibility must be established in a versatile manner to shield the firm from future fluctuations
3. Currently interest rate levels are key external factors calling for greater flexibility in capital budgeting

The following analysis aims to provide insight and prove these propositions right with the tools of a literature review and simple sensitivity analysis.

## 1.1 Methods and structure

The analysis has been conducted based on a review of the appropriate literature. To complete the work and to further present the vast effects of not accounting for flexibility, a few simple examples using traditional capital budgeting methods by varying interest rate levels have also been included. As the issue of capital budgeting has been widely researched in the past, all necessary information can be collected from the right sample of works. It is not within the scope of this thesis to conduct further research. By then combining this available theoretical information and previous empirical research into a comprehensive unity, the value of flexibility can be demonstrated and valuation methods can be critically assessed. The key terms used in the literature search were flexibility, real options, flexibility valuation and interest rates, all within the context of capital budgeting. Using the title and abstract as pruning factors, the sample literature was chosen from the returned search results. The literature review was conducted by utilising a Boolean phrase search in Aalto Finna database and Google Scholar. The main base for the flexibility analysis section was Dixit and Pindyck's (1994) "*Investments under Uncertainty*". From this book the view on versatile flexibility options and the limitations they might face was expanded into further material, by identifying key search terms and utilising the appropriate original sources. Literature on flexibility measures in capital budgeting can concern both liquid and illiquid investment opportunities. Some theories and forms however apply to both, in which case they are presented here only in the context of illiquid investments.

Using a simple model to prove real effects is in itself perhaps obvious, but still necessary. The capital budgeting methods currently utilised by most private sector actors no longer capture the true values of investment projects. By making small alterations we can demonstrate the importance of accounting for flexibility in calculations.

Structurally the analysis will start at the very core of capital budgeting; the traditional methods that have been in place for several decades. Establishing the shortcomings and oversights of the discounted cash flow methods gives weight to the need for flexibility. Then moving on to flexibility analysis in capital budgeting practises; looking into the limitations in place and exploring various forms of flexibility. The assessment of different valuation methods will take place in the context of these background influencers presented. Finally, bringing in an external factor, interest rates, will further demonstrate the imminent requirement for flexibility that is accelerated by the current economic state of the world. As stated before, the analysis will focus solely on the effects regarding the increased requirement for flexibility, not to take a stance on what is causing the current interest rate environment.

## 1.2 Previous works

Identifying the current status quo in capital budgeting is crucial before conducting new analysis. Though flexibility is often thought of as a relatively new concept in capital budgeting, multiple studies and theories have existed for several decades. The valuation and consideration of real options has been brought forward in addition to the traditional methods, such as NPV, IRR and PB (e.g. McDonald and Siegel, 1985; Dixit and Pindyck, 1994; Dreyer and Grønhaug, 2004). The effect of certain environmental factors, such as developments in consumer demand and changes in interest rate levels, has also been previously connected to capital budgeting (e.g. Dixit and Pindyck, 1994; Kulatilaka and Trigeorgis, 2001; Alvarez and Koskela, 2006).

Shortcomings of traditional methods have been widely recognised, but for some reason these realisations have not had a dramatic effect on their popularity (Trigeorgis, 1996; Feinstein and Lander, 2002; Smit and Trigeorgis, 2006). Regardless of the vast extent of the conversation regarding flexibility, it's valuation and inclusion in calculations is still viewed as somewhat of a special feature rather than a solid standard due to the complex nature of valuation models (e.g. Lander and Pinches, 1998; Feinstein and Lander, 2002). With these previous presentations in mind, this thesis will bring theories together in order to prove the benefits derived from adopting flexible practises into capital budgeting. These statements made by previous literature will be further assessed and



utilised as a backbone for the justification and purpose of this paper. First, we discuss the flaws of traditional capital budgeting methods using discounted cash flow approach.

## 2. Pitfalls of traditional methods

Traditional methods of capital budgeting don't succeed in considering all possible outcomes as the project begins to unravel (Denison, 2009). Leaving flexibility out of the calculations may cause management to make serious mistakes in capital budgeting and bypass projects with the highest real potential (Feinstein and Lander, 2002). The use of simple discounted cash flow (DCF) analysis leaves out the value of waiting and revising the investment opportunity as uncertain future outcomes are realised (Lander and Pinches, 1998). Some basic flaws present themselves in the use of DCF methods. Not acknowledging time as a risk measure and relying too blindly on a set hurdle rate leave investments vulnerable to unfavourable environmental changes. Also, by assuming a constant capital structure and passive management these methods undermine the role of managers and their reaction capabilities. Most importantly, growth possibilities, which are significant sources of competitive advantage, are often overlooked with traditional methods. Next, these underlying weaknesses of traditional capital budgeting methods are examined.

### *Disregarding duration*

As the time horizon of an investment grows, the predictability of future cashflows diminishes. This effect has even more relevance in today's volatile markets (Smit and Trigeorgis, 2006). Regarding especially long-term investment projects, the net present value method overlooks the importance and effect of duration. As the time span grows, interest rate volatility in the long run becomes relevant. This issue causes the hurdle rate of initial calculations to be incorrect regarding the later years of project life (Trigeorgis, 1996).

### *Assumption of passive management*

The simple NPV approach also assumes for management to continue their passive approach on investments even when circumstances alter (Keswani and Shackleton, 2006). As the initial capital outlay has been made, NPV does not consider the possibility

of alterations, the use of real options, which will be discussed in detail later when moving on to the flexibility analysis. These modifications can be e.g. abandonment, capacity or output changes (Dreyer and Grønhaug, 2004). The assumption of this static state in investment activities is a close-minded approach to valuation.

#### *Rigid hurdle rate*

Though cashflows might be modified to project dynamic decision-making by management, the faulty in the NPV method often stems from the rigid use of the discount rate, the WACC. Flexible design of a project enables it to obtain a lower hurdle rate since it can better be modified to respond to changes in uncertain factors (Lander and Feinstein, 2002). These possibilities are overlooked, and the discount rate is not adjusted accordingly.

#### *Assumption of a constant capital structure*

Another pitfall of the traditional methods utilising the set hurdle rate, WACC, in valuation is that the assumption of a constantly remaining capital structure in a longer project is highly unrealistic. Firms will shift their relation of debt and equity according to market movements and affordability (Graham and Harvey, 2002).

#### *Overlooking growth opportunities and competitive advantage indicators*

What brings the most dramatic difference between traditional, rigid methods of capital budgeting and the flexible take of real options, are projects with initial negative net present values. These projects, though seemingly unattractive, might turn out to be in a key position for unlocking future growth potential (Trigeorgis, 1996). Overall, as consumer demands are persistently changing, and at an accelerating pace, maintaining competitive advantages is even more crucial. For a firm to remain at the top, it must be able to satisfy these altering needs by providing better services. NPV and other traditional methods overlook such indicators in projects, like quality enhancement and response time (Aggarwal et. al, 1991). These are hard to directly quantify and may not directly affect margin levels, but are still necessary steps for sustained demand.

On a more general note, traditional methods are also using the same set WACC for all projects, thus assuming that the risk level of all projects is similar to the firm's as a

whole (Trigeorgis, 1996). Investment opportunities should be valued uniquely, as heavy dispersion among projects may exist. A very basic obstacle in traditional capital budgeting is that the conversion of all benefits derived and costs incurred, generated cashflows and intangible effects can be simply impossible. Quantifying effects such as increased brand power or positive firm image and then incorporating them into simple NPV calculations is not feasible. Also, traditional methods are seen to be best suited for environments with low levels of uncertainty and risk; this does not exactly correspond with the current state of the world economy (Trigeorgis, 1996).

Everything discussed above gives weight to the increased requirement for flexibility in capital budgeting. New valuation methods for projects can provide more reliable knowledge, lead a firm to the optimal decision and solve some of the issues faced by using traditional NPV and DCF methods. The next section will demonstrate how flexibility can in practise be incorporated to capital budgeting to avoid these pitfalls.

### 3. Flexibility analysis in capital budgeting

As the very concept of flexibility is harder to comprehend than simple NPV analysis based on discounted cash flows, flexibility needs to first be defined. When the benefits and content of flexibility have been identified, the value of these flexibility options needs to be estimated and quantified. Lastly, some basic limitations apply to the use and profitability of these options. In this section all three aspects regarding flexibility analysis in the context of capital budgeting are presented and evaluated critically.

#### 3.1 FORMS OF FLEXIBILITY

Flexibility as a concept entails many different implications. It can be seen as an option to choose the timing of each investment freely (Kort et. al, 2010), or as the possibility of alterations as future circumstances begin to realise (Kulatilaka and Trigeorgis, 2001). Flexibility can be viewed as company-specific; a resource specialised in the adjustment and full exploitation of a single actor's opportunities (Dreyer and Grønhaug, 2001). Before we arrived at one simple definition by combining alternate sources: flexibility can be defined as 'wiggle room' in the breadth of capacity, operation level, production

outputs, volume and timing (Dixit and Pindyck, 1994; Dreyer and Grønhaug, 2004). Due to recent developments in the overall investment environment, flexibility has experienced a rise in popularity and is now viewed as a way to obtain competitive advantages over rival companies. Some forms of flexibility can also be area- or industry-specific, or simply not as important in all fields of business (Dreyer and Grønhaug, 2004). In some fields investing in flexibility might not even be worthwhile. These are industries with low uncertainty in operations and demand (Kulatilaka and Trigeorgis, 2001). However, the current economic environment has vast effects and touches upon all industries. It is crucial to not only understand but also value these flexible options correctly and seize the possibilities they bring in order to maintain competitiveness of the firm.

These options can either occur naturally or require additional capital outlay (Baldwin and Clark, 1992). It is crucial for firms to have high-quality knowledge on their respective operating markets. Evaluating whether to invest in a more expensive but flexible investment rather than the rigid one with lower initial cost is a fundamental skill in competitive industries (Feinstein and Lander, 2002). Now, we examine the different realisations of flexible options in investments presented in different publications. Some of these forms have been recognised as general flexibility in operations, but as we focus on illiquid investments, such as manufacturing facilities, the same options and their valuation can be applied in capital budgeting for these projects.

### *3.1.1 Choice of timing*

In most investment decisions, timing is crucial. Finding the correct position for new market entry or construction might make or break a project. Even if a project already shows positive NPV, it might be more profitable to wait for better conditions or new available information regarding the market (Kulatilaka and Trigeorgis, 2001). Another implication of timing derives from the competitive forces at play; early investment and the risk it bears might be optimal if there is danger of otherwise losing the opportunity to a competitor (Smit and Trigeorgis, 2006).

The option to defer investment to a later time is indeed a key form of flexibility, though not always a possibility. Strategic focus or aggressive competition might force a

company to make quick investment decisions (Dixit and Pindyck, 1994). Generally the first investor, a pioneer in a sense, collects the largest financial compensation among the rival group when strategic effects of investing exist. However, when uncertainty levels are high, early commitment might not be the best option regarding future outcomes. If a spill-over effect regarding information exists in the field, it might be more beneficial to be a follower rather than the leader (Chevalier-Roignant et al., 2011). In these situations second-to-entry firms might actually find cost benefits from lower need for consumer analysis or R&D projects.

Deferring investment is however, usually achievable. It may incur some added costs, which include the risk of other market entrants and lost possibilities, but as previously stated, new market information can be worth the wait. Being able to wait for the investment opportunity's true potential to be revealed can salvage the company from making rash decisions that can turn out to be costly (Dixit and Pindyck, 1994). What most commonly incentives firms to exercise the possibility of deferring investment are uncertainty over demand or interest rates and the lack of sufficient internal capital (Chittenden and Derregia, 2013). The value of waiting is generally higher when interest rate uncertainty is high and the overall duration of the project is long (Trigeorgis, 1996). This indication applies perfectly to the capital budgeting decisions discussed within this paper.

### *3.1.2 Option to expand or contract operations*

When the investment has already been carried out, and operations are functioning at the initial intended capacity, companies examine the realisation of their projected demand. If they find that demand is higher than expected, they might consider investing in further capacity to satisfy this demand. On the contrary, if demand is lower than projected at initiation, a firm may choose to contract operations in order to save on variable costs (Kulatilaka and Trigeorgis, 2001). Expanding operations is a partially irreversible investment; it requires further capital outlay on e.g. manufacturing hardware. Contracting can however be reversed without significant cost, if it is executed by leaving facilities idle and not by selling equipment.

Adding capacity usually has the initial effect of increasing profit margins, as fixed costs remain the same but there are more units to cover the incurred costs. Eventually the leap to larger fixed costs must be made and often the situation of diminished returns comes into play (Dixit and Pindyck, 1994). So, the alterations in demand should be considered somewhat permanent in order to justify irreversible expanding of operations.

### *3.1.3 Temporary shutdown*

The basic idea behind a temporary shutdown is simple; as derived revenues are less than variable costs, operations should be seized. This option however is rarely examined in the initial process of capital budgeting (McDonald and Siegel, 1985). Switching the mode of operation from active to shutdown is a phenomenon that may also be witnessed regularly in seasonal production facilities. This may result from environmental conditions or known seasonal fluctuations in demand. No cash flows are generated in the shutdown mode, but no variable costs are incurred. In this case the possible shutdown costs as well as costs incurred from restarting operations must be included in calculations (Kulatilaka and Trigeorgis, 2001). As Dixit and Pindyck (1994) simplify the issue, the project will be held active at all times when the profit surpasses the flow cost of operations. This suggests that this type of project ultimately gives an infinite set of options for function time (McDonald and Siegel, 1985). In some situations temporary shutdown is simply impossible. If the project requires highly educated staff, and contracts have to be terminated, the firm might lose the required knowledge, which could be extremely challenging to reacquire (Dixit and Pindyck, 1994).

However, these implications are only true if we assume a zero-level of shutdown and restart costs, which is not a very realistic situation. When not in active use, invested capital is subject to corrosion. Both physical assets, such as machinery and facilities, as well as intangible assets, such as customer loyalty and brand power fade with time if left unused or unattended. With physical assets lack of maintenance is an issue, and with the intangible side customer recollection loses its strength. To evade higher restarting costs due to the rusting of capital, maintenance procedures can be taken up. This may require an initial fixed cost in addition to the on-going costs, but may prove to be valuable if it lowers the cost of activating operations significantly (Dixit and Pindyck, 1994). With

intangible assets this is considerably harder, as brands need to take part actively in their consumers' lives in order to stay relevant.

#### *3.1.4 Option to abandon*

If future prospects are seen as highly negative, a firm may consider abandoning the project to obtain salvage value. Switching costs are also of high relevance here. If the cost incurred in order to execute the desired abandonment, and acquire salvage value, reaches the level of the salvage value itself, a firm might be forced to continue operations even if operations are no longer profitable. By generating cash flow, though unprofitable, a firm can still cover fixed costs with them, even partially (Kulatilaka and Trigeorgis, 2001). Permanent abandonment is an extreme choice, as re-entry to the field will require a whole new investment if facilities are discarded or resold. High costs of abandonment need to be considered already when the business model is formed, as they also heighten the entry threshold. A higher price point for the production output must be obtained to cover the risk of forced abandonment (Dixit and Pindyck, 1994). In some cases, if assets used in operations are not company-specific, a firm may be able to exercise the option of abandonment at market price or alternatively only with a relatively small discount. Liquefying the assets of the project can be carried out by selling them on the open market to competitors or by putting them to use in another investment (Keswani and Shackleton, 2006). The effortlessness of the liquidation process depends on the size of the industry, the uniqueness of the produced output and the existence of a secondary market for the assets.

#### *3.1.5 Flexibility of value chain*

The capacity to alter manufacturing facilities to produce different outputs provides a company with leeway and is forgiving to imperfectly conducted market analysis. Constant renewal of products is crucial especially in certain industries, such as technology. Life cycles of these products are shortening constantly, and customers are becoming increasingly demanding but also willing to update their equipment (Dreyer and Grønhaug, 2004). Production facilities that are designed to endure technological updates and modifications help firms to better equip themselves to be able to answer the constantly altering demand.

### *3.1.6 Volume flexibility*

When there is uncertainty over demand, being able to incrementally increase capacity shields the company (Dixit and Pindyck, 1994). This relates to the scale economies theory presented earlier as a limitation to flexibility. Volume flexibility is defined as the option to produce either above or below the original capacity. This option enables a firm to adjust to environmental factors affecting the demand of products, as well as adapting to changes in raw material prices and availability (Dreyer and Grønhaug, 2004). Volume flexibility differs from the previously presented options of expanding and deferring. Exercising this option does not require additional costs of switching, but the production facilities are designed to endure small alterations. The downfall of volume flexible production is that if demand remains at a stable level, the firm is holding excess capacity, which is idle during these time periods.

### *3.1.7 Growth possibilities*

New investments can have strong strategic importance, if they serve the firm as test rounds or experiments in new technology or markets. Taking into account the domino effect caused by the initial capital outlay may change the course of a project that seemed unattractive when evaluated separately. If the full potential deriving from the first-stage investment is not examined and included in calculations, firms may lose significant opportunities and be unable to sustain competitive advantage (Trigeorgis, 1996). Though the most difficult to quantify, growth options can turn out to be the most valuable. The value of being able to create a prototype that has excessive future potential is an example of such a case (Busby and Pitts, 1995). Investments in R&D projects can't be valued as a simple one-time deal; there are several applications of strategic importance to be examined (Smit and Trigeorgis, 2006).

## 3.2 FLEXIBILITY VALUATION IN PRACTICE

Generally, if the business environment of a firm is competitive and withholds factors of uncertainty, flexibility is valuable (Dreyer and Grønhaug, 2004). Using models to value acquired real options from investment opportunities enables a firm to account for active project management and interdependencies between various separate projects (Lander and Pinches, 1998). This is a simple suggestion, and the theory supports logic. When



environments are more turbulent, these flexible options become more prominent. As with all investment, there is a time issue also regarding the realisation of these real options that needs to be taken into account. Evaluating the optimal time to respond to environmental changes in order to obtain sustainable advantage over competitors is crucial (Dreyer and Grønhaug, 2004). The development of these alternative methods is essential for enabling the use of real options and their valuation to become a standard in capital budgeting practises (Lander and Pinches, 1998). Many different methods have been examined in order to find the optimal for valuing the benefits derived from obtaining these flexible real options. Next, we examine some methods that have proved most relevant and applicable.

### *3.2.1 Sensitivity analysis*

The very basic approach to any uncertain situation is to run a sensitivity analysis. By examining the probability of the occurrence of each decision point, a firm can see the vulnerability the project has regarding changes in influencing factors (Lander and Pinches, 1998). Changing the used hurdle rate or the cash flow forecasts is an established tool to battle uncertainty in capital budgeting. Using sensitivity analysis or combining it with different scenarios is the most common approach to evaluating uncertainty (Chittenden and Derregia, 2013).

### *3.2.2 Decision trees and influence diagrams*

One of the signature features in flexible investments is that they form a sequence of new possibilities that are only viable after the initial capital outlay, the first project, has been executed. So, capital budgeting should be able to value these derived opportunities and also understand the interdependencies between outcomes. Decision trees can achieve this, and by also simultaneously giving direction for strategy forming. Pitfalls in these decision-making models are the use of an incorrect discount rate and the complexity that grows with size. Also, evaluating the probabilities of real events correctly can turn out to be a challenge (Lander and Pinches, 1998).

Decision problems and their solving rely on the knowledge obtained by the decision maker. By presenting the structure of the issue at hand and demonstrating the current knowledge level, influence diagrams attempt to only bring forth the relevant factors of

the process. Excluding the excess possibilities that are not feasible makes influence diagrams more concise in comparison to decision trees. However, the appropriate use of influence diagrams requires uncertainty modelling and probability distributions to be available (Lander and Pinches, 1998).

### *3.2.3 Weighted average discount rate (WADR)*

This analysis method presented by Feinstein and Lander (2002) provides a valuation tool for simple real options. The only requirement for the utilisation of the WADR method is that the discount rate is altered to suit the period where flexibility incurs. This discount rate is established by comparison to a replica portfolio, which consists of a risk-free investment and a stake in a rigid project. By computing a weighted average discount rate for this portfolio, we arrive at the correct flexible discount rate to be used in the period of flexibility.

This method also only applies to projects where flexibility occurs at one imminent time, and is later followed by rigidity. The WADR has been identified as an easy stepping stone, a first level towards the use of more intricate valuation methods for flexibility programmes. Also, the similarity to traditional NPV computing lowers the threshold for managers to account for flexibility (Feinstein and Lander, 2002).

### *3.2.4 Applications to the NPV method*

When considering a flexible project with different operation modes, such as capacity or output, incorporating switching costs of production is crucial. Without these switching costs the value of a flexible investment can be viewed as the value of a rigid one, added with the future option values (Kulatilaka and Trigeorgis, 2001). In this case the flexible project would be the more beneficial choice in all possible scenarios. This is not the case as switching costs may tilt the scales, if the option to shift production is wrongly timed or executed. So, we come to this simple suggestion: if the value of the flexible project is greater than the sum of the rigid NPV and incurred switching costs of option realisation, the additional investment should be made.

In order to incorporate the needed flexibility factors to the traditional methods used in capital budgeting, the band of uncertainty on which the future cashflows lay, must be

established. By utilising this possibility factor, we can use real option theory to value flexibility. The static NPV describes the known cashflows, and the value of real options serves as the unpredictable cashflows. Busby and Pitts (1995) present this simple model to expand the net present value method to cover flexibility:

**Expanded NPV = Static NPV + Value of the real options**

Smit and Trigeorgis (2006) also provide an application to the traditional NPV, incorporating both strategic and flexibility value:

**Expanded NPV = Direct NPV + Strategic value + Flexibility value**

The direct NPV here is the basic approach; cashflows obtained by passive management. Strategic value stems from competitive interactions; what the firm has gained by cutting out or outperforming competition. The added value of active project management is depicted with flexibility value. This outlook is similar to the one presented by Busby and Pitts, but defines the value of real options further, splitting them to strategic effect and pure flexibility.

Combinations to and modification of the NPV method bring a sense of familiarity to managers. These methods also separate the value of the flexible option, making it into a tangible benefit easier to comprehend and quantify. There are however, some limitations that might affect the very feasibility of acquiring flexibility in projects, as discussed in the section below.

### 3.3 CHALLENGES TO FLEXIBILITY

Most investments are considered to be irreversible or at least partially irreversible. This is especially the case in the illiquid investments discussed in this paper, as they are often real estate or construction work. Due to their nature, these investments need to be assessed not only by using the traditional NPV, IRR or PB methods, but also by including in the value of flexible options. In some cases, this type of analysis exposes the irreversibility of a given project. When investments are considered to be completely

solid, flexibility is not given any thought but rather often treated as an expensive safety net (Feinstein and Lander, 2002). However, in the context of our current environment, there might not be that many totally solid investments left to be made. Further examination into obtaining possibilities of future alterations or even deferring should be a crucial part of capital budgeting (Busby and Pitts, 1995). Next, we examine the different limitations affecting the integration of flexibility into capital budgeting practises.

### *3.3.1 Added expenses*

What limits firms from putting capital into flexibility measures in most cases is the uncertainty of the need to utilise the obtained alternatives. Knowledge on future outcomes is in no way obtainable; this is the definition of uncertainty. So, probability analysis comes into play. If the environment in no point of the project changes in a way that would require modification to the project, the flexibility brings no actual added value. In this case, the flexible project has the same value as a rigid project, which could have been realised with lower cost (Kulatilaka and Trigeorgis, 2001).

### *3.3.2 Managerial ego influence*

Another limitation stems from human nature. When only at the very beginning of an investment project, no manager is exactly willing to already plan for its failure. Managerial ego might come into play, especially if there are personal factors influencing the willingness to realise the original investment plan. Same as the success of a project initiated personally gives the manager a feeling of achievement, the failure of a project also has personal effect (Collins and Willingham, 1977). The treatment of an investment as a potential failure from the very beginning may also cause lower commitment within the organisation as a whole. This can be extended from the paper by Denison (2009), stating this effect exists with management.

Including the value and even the simple possibility of real options into the capital allocation process from the beginning may prohibit the escalation of commitment regarding the project. What is meant by escalation is the increased commitment after the project has been initiated, making managers and the whole organisation more reluctant to abandon the investment. After receiving initial negative feedback, the

manager still continues to commit resources due to this effect, because their mind is strongly set on the implementation (Denison, 2009). So, to summarise, if management becomes aware of real options before conducting the investment, flexibility benefits can be achieved. However, if the project has already been initiated, managerial ego comes into play and serves as an obstacle to flexibility.

### *3.3.3 Integration to corporate strategy*

In order for flexible capital budgeting to be effective, the mind-set of flexible operations must be implemented throughout the whole corporation. For a firm to be able to adopt flexibility in its investments, the execution must first be a feasible possibility. There is no use in accounting for changes in the product mix or manufacturing capacity in initial capital budgeting, if the design and marketing departments don't possess the needed capabilities to realise these plans (Aggarwal et. al, 1990). Of course capital budgeting even its traditional form has to be an integrated part of strategy, but adopting new practises is often a challenge, especially when benefits are hard to quantify directly.

### *3.3.4 Economies of scale*

The benefits derived from economies of scale are clear and simple. By focusing resources on one specific area or field corporations can achieve cost benefits and reach higher efficiency. There is however, a trade-off arising from obtaining these benefits; losing flexibility in the process. Economies of scale often require large, one-time investment in order to realise cost benefits as fast as possible. Flexibility arises from the possibility to defer or alter investment, and this is better achieved by gradual project realisation. Executing the project at once will in most cases carry a lower total cost, but will also offer less room for alterations along the way (Kort et. al, 2010). As uncertainty is increased, the additional costs of the more flexible, gradual project containing multiple smaller rounds of investment become more inconvenient for the company to carry. This implication leads to companies favouring the undertaking of larger projects as uncertainty levels heighten, even if it requires waiting for the needed information to become available (Dixit, 1993). Obtaining economies of scale might be worth the wait, but it could also lead to the firm losing valuable opportunities that only exist within a certain scope of time.

### *3.3.5 Balancing continuity and flexibility*

There lies an easily recognisable issue in focusing on flexibility for operations. Firms must also establish a sense of continuity in their business, and constantly gearing up for possible changes is somewhat of a contradiction against this (Dreyer and Grønhaug, 2004). The same trade-off is present in the battle between flexible operations and high productivity. Flexibility in itself cannot be the goal, since it is the aim of the firm to be profitable. Thus, flexibility cannot be sought after by diminished productivity in the process, but the resources of the firm should still be in the most effective use possible (Volberda, 1998). Corporate culture might also suffer from constant change, if it is not established as a viable part of operations.

## 4. Effect of interest rate fluctuations

In the aftermath of the 2008 financial crisis and the following sovereign debt crisis, central banks began targeting interest rates as a tool of control and encouragement (Roche et al. 2015). Though market interest rates are not directly a factor in capital budgeting, their role is clear in setting the used hurdle rate, which is the WACC (Dixit and Pindyck, 1994). Monetary policy has lately set a downward trend on their interest rates, thus creating a similar pressure on the required rates of return for a given investment (Roche et al. 2015). This creates a certain illusion of greater profitability, resulting to decisions that might turn out to be unfavourable in the long run. As rates eventually bounce back closer to their pre-crisis starting level, loans taken with floating rates will become more expensive, thus also increasing the cost of capital of a given investment. Though it has been estimated by the US Federal Reserve that the eventual rise of interest rates will be slow and gradual, even significantly lower levels will tilt the scale and make a long-term illiquid investment unprofitable. It is indeed yet to be seen, how much of the downward trend of interest rate levels will become long-lasting (Johannsen and Mertens, 2016).

In a wider context, the actions of central banks provide market signals, which also augment the estimates of cashflows and obviously, the availability of capital as investment opportunities are analysed. These accommodative monetary policies boost the will to invest through more available capital and seemingly higher rates of return.

This enables for more projects to become profitable and obtain a positive NPV; however, the reality is that there is not enough capital to carry out all of these newly emerged projects (Roche et al. 2015).

As the time horizon of the investment project grows, this influences its risk profile. The duration of a project is a direct measure of risk (Barney and White, 2003). This derives from the simple suggestion that the future cashflows stretching further into the future are more volatile and harder to predict (Cornell, 1999). A recent study conducted by Chittenden and Derregia (2013) revealed that firm size affects the priority given to different types of volatility in markets. Small firms find uncertainty over interest rates vastly more significant than large firms.

The effect of high interest rates on capital budgeting has been widely examined in the past. As interest rates reach higher levels, capital allocation becomes an even larger issue, as resources to invest become increasingly scarce. Projects need to be categorized and eliminated based on their expected return. In this type of situation, projects not only delivering sufficient future cash flow streams, but also generating new growth opportunities, are considered to be of higher value. These growth opportunities are real options deriving from the original investment. They are taken into account as directional factors on top of the number-pure approach given by traditional project valuation (Kester, 2001).

Interest rate uncertainty affects capital allocation decisions in two ways. Firstly, fluctuations, both the rise and the fall, impact the expected future cashflows. Secondly, as interest rates can't be accurately forecasted, uncertainty regarding these rates creates a value to wait for new information about the future direction of interest rate fluctuations (Dixit and Pindyck, 1994). If we now focus on the situation currently at hand, the eventual rise of interest rate levels will have a negative impact on the discounted predicted cashflows of a given investment project. However, as Dixit and Pindyck (1994) further demonstrate, overall uncertainty regarding the interest rate level increases the expected value of the investment. The fluctuations make the investment more attractive. So, it is not necessarily the actual level of interest rates, but

their stability that has a more direct effect on capital budgeting policies (Dixit and Pindyck, 1994).

In the current environment investors are enjoying low interest rates and more affordable loan capital. Projects are taken on using a set hurdle rate, which is affected by the current rate environment, and as a result required returns are relatively low in comparison to the situation two decades ago. After project initiation, increases in interest rates will diminish the NPV of the project. Measuring this interest rate risk can be done by a duration gap analysis, which utilises the time horizon of the acquired debt financing and compares it to the overall project life. By striving for a zero duration gap, firms can immunise themselves from interest rate risk. However, obtaining the debt financing required to achieve this goal in reasonable terms is challenging to execute in practise (Barney and White, 2001).

The WACC utilises the relation of debt and equity to establish the average cost of capital that is available for the firm to invest. Here, to examine the effects of shifts in interest rates in two alternative production facility investment projects, we assume two things:

- 1) cash flows (profit) remain constant throughout the investment time horizon
- 2) capital structure remains constant

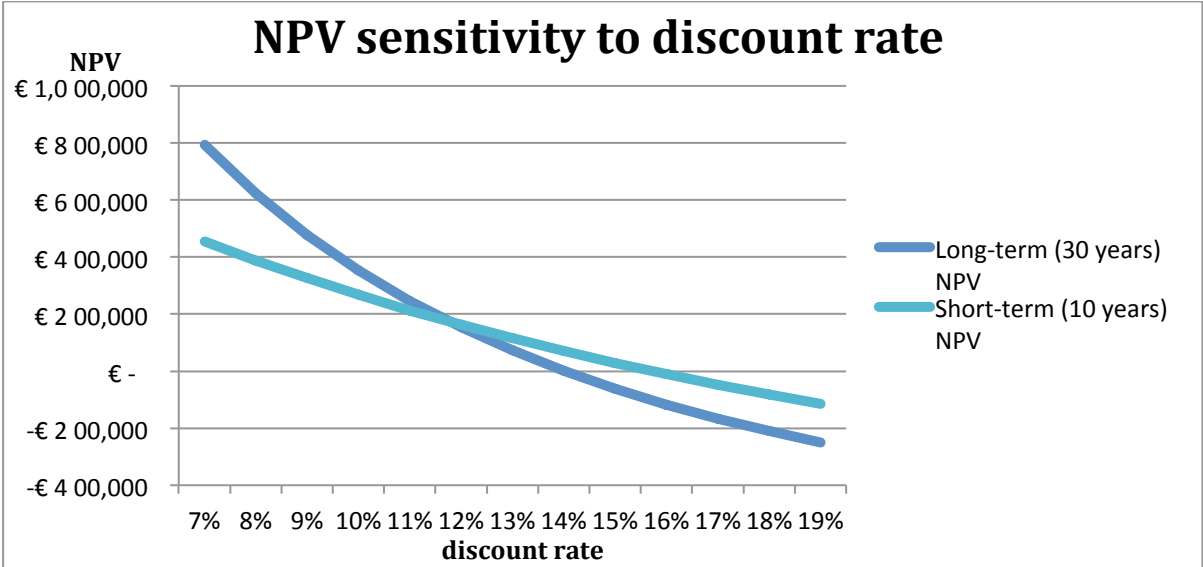
→ the financing decision is separate from the investment decision and not considered here; if cash flows would be altered in addition to the hurdle rate, the effect of interest rates rising would be double-counted (in presented scenario including flexibility)

Project variables	short-term	long-term
time horizon	10 years	30 years
annual cash flow	€ 200 000	€ 150 000
scrap value	€ 100 000	€ 100 000
initial capital outlay	€1000000	€1000000

As the graph below (Graph 1) demonstrates, long-term investments are more sensitive to changes in discount rates due to the longer time horizon. The discount rate is set according to the WACC. As mentioned before, one of the components of the hurdle rate, the WACC, is the risk-free rate, which is a market interest rate.



Graph 1



What is also notable about the results of this simple sensitivity analysis is that the slope of the long-term project is steeper than that of the short-term. Thus, a faulty decision regarding investments with long time spans can have more dramatic effects if the initial hurdle rate proves to be wrong. In comparison to the base case of an 11% discount rate, even a misestimate of 2 percentage units (resulting to a discount rate of 13%) lowers the NPV of the long-term project by 61% (comparison to 46% in the short-term, see Appendix 1). As these misevaluations are increasingly feasible in our uncertain environment, the possibility of interest rate fluctuations needs to be examined thoroughly in the capital budgeting process.

Now, if we consider the situation in which the investment of 30 years contains a flexible option regarding the rental agreement of the facility. The firm can lease the space for a fixed term of 30 years, or it can choose to retain an option of revising the decision after the first 20 years of operations. The rent would be 3000€ higher annually, if the firm chooses the flexible alternative. If after 20 first operating years management discovers that the initial discount rate of 11% was in fact misevaluated due to interest rate levels bouncing back, the correct rate for the 10 remaining operating years would be discounting with a rate as high as 20%. There is a secondary market for the machinery and after 20 years it could be sold off to a competitor 700 000€. If operations run for the whole time span of 30 years, scrap value is only 100 000€. Within the scope of this particular scenario, it would indeed be more profitable to acquire the flexible option of

keeping the renting for the last 10 years open (see Appendix 2). Flexibility is in itself valuable here. The quantifiable benefits derived from realising the option to drop the rental agreement after the initial 20 years surpass those achieved by running operations for the full initial duration of the project. This example is of course only one scenario especially created to demonstrate the value of flexibility. What it essentially enables is for the manager to re-evaluate their decision after 20 years. This can be done by comparing the cashflows deriving from ending operations or continuing production for the remaining ten years (see Appendix 2). The same basic idea can be extended to multiple alternate scenarios; different time horizons and investment projects, as well as different forms of flexibility options.

As mentioned in previous sections, interest rates are only one parameter affecting the viability of capital budgeting calculations and decision-making. It was chosen to be examined here due to the expected eventual shifts in the interest rate levels, which may cause severe effects on long-term capital commitment projects.

## 5. Conclusions

The areas examined within this thesis shed light on the different forms of flexibility and limitations to their acquirement. Combining the findings of Dixit and Pindyck (1994) with Kulatilaka and Trigeorgis (2001) present an integrated body to the further analysis of flexibility valuation. Identifying the optimal form of flexibility is key in obtaining and sustaining competitive advantage in turbulent market situations. Flexibility provides a way to shield businesses from uncertainty.

As conditions grow increasingly uncertain, flexible options are a central tool to survive market fluctuations and continue profitable operations. This was demonstrated with the conducted sensitivity analysis and by the realisation of the flexible option as conditions shifted. The presented various ways of obtaining this flexibility in projects serve as a starting point for any capital budgeting process. Traditional methods and their use of discounted cashflows as a single measurement are insufficient indicators in valuation. By focusing on especially those qualities of traditional methods that can be gradually eliminated by integrating flexibility into capital budgeting, this thesis then set out to

describe the process in practise. Providing only imperfect data, which overlooks possibility of abandonment, expansion and future growth potential, the use of traditional methods in their standard form can more easily lead to incorrect decisions and loss of profit. With these arguments, flexibility in investment projects, especially in ones spanning over long periods of time, is a mandatory advance to be implemented as a standard within accounting departments.

Currently, valuation methods are relatively complex and often require additional knowledge in order to be executed correctly. Methods presented within this paper were identified as the best functions currently available. Simplifying the outcomes of a project enables them to be examined and understood. Producing usable, solid data and analysis on different options is crucial, as the benefits derived from exercising them are often otherwise hard to comprehend or compare. The very nature of capital budgeting is to provide profitability figures, so the advantages of flexibility must be quantified.

The next step for the full incorporation of flexibility in capital budgeting is convincing management of the benefits effecting profitability figures. Developing valuation methods that can be implemented into decision-making with relative effort is essential. The main limitation of this thesis was the availability of recent data on the popularity of flexibility. Further research on the attitude towards flexible methods, sharing of best practises and clear documentation within firms is key in developing capital budgeting to better equip firms within the current environment.

## 6. References

- Aggarwal, R., Edward J. and L.E. Mellen, 1991, Justifying Investments in Flexible Manufacturing Technology: Adding Strategic Analysis to Capital Budgeting Under Uncertainty, *Managerial Finance*, 17(2), 77-89
- Alvarez, L. H R., and E. Koskela, 2006, Irreversible Investment under Interest Rate Variability: Some Generalizations, *The Journal of Business*, 79 (2), 623-644
- Baldwin, C.Y. and K. B. Clark, 1992, Capabilities and Capital Investment: New Perspectives on Capital Budgeting, *Journal of Applied Corporate Finance*, 5 (2), 67-82
- Barney, L.D. and H. White, 2003, Project-specific Financing and Interest Rate Risk in Capital Budgeting, *The Engineering Economist*, 48(2), 169-182
- Brounen, D., A. de Jong, and K. Koedijk, 2004, Corporate Finance in Europe: Confronting Theory with Practice, *Financial Management* 33, 71-101.
- Brunzell, T., Liljebloom, E. and M. Vaihekoski, 2013, Determinants of capital budgeting methods and hurdle rates in Nordic firms, *Accounting and Finance*, 53 (1): 85-110
- Busby, J. S., and C.G.C. Pitts, 1995, Investment and unpredictability: Why yardsticks mislead us, *Management Accounting*, 73(8), 38
- Chevalier-Roignant, B., Flath, C.M., Huchzermeier A. and L. Trigeorgis, 2011, Strategic Investment under Uncertainty: A Synthesis, *European Journal of Operational Research*, 215, 639-650
- Chittenden, F. and M. Derregia, 2013, Uncertainty, Irreversibility and the Use of 'Rules of Thumb' in Capital Budgeting, *The British Accounting Review*, 47, 225-236
- Collins, F. and J. Willingham, 1977, Contingency Management Approach to Budgeting, *Management Accounting*, 59(3), 45
- Cornell, B., 1999, Risk, Duration and Capital Budgeting: New Evidence on Some Old Questions, *The Journal of Business*, 72(2), 183-200
- Denison, C. A., 2009, Real Options and Escalation of Commitment: A Behavioural Analysis of Capital Investment Decisions, *The Accounting Review*, 84(1), 133-155
- Dixit, A.K., 1993, Choosing Among Alternative Discrete Investment Projects under Uncertainty, *Economics Letters*, 41, 265-268
- Dixit, A.K. and R.S. Pindyck, 1994, *Investment under Uncertainty*, 8-9, 48-55, 186-187, 213-244, 1<sup>st</sup> edition, Princeton, New Jersey, Princeton University Press
- Dreyer, B. and K. Grønhaug, 2004, Uncertainty, flexibility and sustained competitive advantage, *Journal of Business Research* 57, 484-494
- Feinstein, S. P. and D.M. Lander, 2002, A Better Understanding of Why NPV Undervalues Managerial Flexibility, *The Engineering Economist*, 47 (4), 418-435
- Graham, J. R., and C. R. Harvey, 2002, How do CFOs make capital budgeting and capital structure decisions?, *Journal of Applied Corporate Finance* 15 (1), 8-23.
- Johannsen, B.K. and E. Mertens, 2016, The Expected Real Interest Rate in the Long Run: Time Series Evidence with the Effective Lower Bound, *FEDS Notes*, US Federal Reserve

- Kester, C.W., 2001, *Today's Options for Tomorrow's Growth*, Real Options and Investment Under Uncertainty: Classical Readings and Recent Contributions, 33-46
- Keswani, A. and M.B. Shackleton, 2004, How Real Option Disinvestment Flexibility Augments Project NPV, *European Journal of Operational Research*, 168, 240-252
- Kort, P. M., Murto, P. and P. Grzegorz, 2010, Uncertainty and Stepwise Investment, *European Journal of Operational Research*, 202 (1), 196-198
- Kulatilaka, N. and L. Trigeorgis, 2001, *The General Flexibility to Switch: Real Options Revisited*, Real Options and Investment Under Uncertainty: Classical Readings and Recent Contributions, 179-198
- Lander, D.M. and G.E. Pinches, 1998, Challenges to the Practical Implementation of Modeling and Valuing Real Options, *The Quarterly Review of Economics and Finance*, 38, 537-567
- McDonald, R.L. and D.R. Siegel, 1985, Investment and the Valuation of Firms When There is an Option to Shut Down, *International Economic Review*, 26(2), 331-349
- Mukherjee, T. K. 1991, Reducing the Uncertainty-Induced Bias in Capital Budgeting Decisions – a Hurdle Rate Approach, *Journal of Business Finance and Accounting*, 18 (5): 747-753
- Roche, G.A.G., Lwango A. and G. Vuillemeys, 2015, Entrepreneurial Miscalculation and Business Cycles: How Interest Rate Targeting Distorts Capital Budgeting, *Review of Political Economy*, 27 (4), 624-644
- Smit, H.T.J. and L. Trigeorgis, 2006, Real Options and Games: Competition, Alliances and Other Application of Valuation and Strategy, *Review of Financial Economics* 15, 95-112
- Trigeorgis, L., 1996, *Real Options: Managerial Flexibility and Strategy in Resource Allocation*, 1<sup>st</sup> edition, Cambridge, MIT Press
- Volberda, H.W., 1998, *Building the flexible firm – how to remain competitive*, Oxford, Oxford University Press

## 7. Appendixes

*Appendix 1: Sensitivity analysis of NPV by altering discount rates, comparison to base case of 11%, short-term and long-term project*

discount rate	short term NPV	comparison	long term NPV	comparison
7%	€ 455 551,24	214%	€ 1 018 181,24	291%
8%	€ 388 335,63	182%	€ 803 293,79	230%
9%	€ 325 772,62	153%	€ 625 200,81	179%
10%	€ 267 467,75	126%	€ 476 087,21	136%
<b>11%</b>	<b>€ 213 064,85</b>	<b>100%</b>	<b>€ 350 018,43</b>	<b>100%</b>
12%	€ 162 241,93	76%	€ 242 448,83	69%
13%	€ 114 707,53	54%	€ 149 866,54	43%
14%	€ 70 197,51	33%	€ 69 535,16	20%
15%	€ 28 472,20	13%	-€ 695,48	0%
16%	-€ 10 686,14	-5%	-€ 62 528,91	-18%
17%	-€ 47 475,54	-22%	-€ 117 325,78	-34%
18%	-€ 82 076,29	-39%	-€ 166 181,52	-47%
19%	-€ 114 652,79	-54%	-€ 209 984,81	-60%

*Appendix 2: The case of the flexible option regarding the rental agreement of the facility*

year	Flexible option	Rigid option
0	-1000000	-1000000
1	132432	135135
2	119308	121743
3	107485	109679
4	96833	98810
5	87237	89018
6	78592	80196
7	70804	72249
8	63787	65089
9	57466	58639
10	51771	52828
11	46641	47592
12	42019	42876
13	37855	38627
14	34103	34799
15	30724	31351
16	27679	28244
17	24936	25445
18	22465	22923
19	20239	20652
20	18233	18605
SCRAP	700000	
PV (remaining 10 years + scrap)		645021
<b>NPV</b>	<b>870609</b>	<b>839521</b>

*Appendix 3: Overview on the sources of the literature review*

Year	Author(s)	Title	Journal/publisher (journal quality level)	Key ideas utilised
1991	Aggarwal, R., Edward J. and L.E. Mellen	Adding Strategic Analysis to Capital Budgeting Under Uncertainty	Managerial Finance (1)	Identifying and valuating benefits that are hard to quantify and have high strategic relevance, limitations of traditional methods
2006	Alvarez, L. H R., and E. Koskela	Irreversible Investment under Interest Rate Variability: Some Generalizations	The Journal of Business (1)	Irreversible investment decisions in conditions of uncertainty, effect of interest rate fluctuations
1992	Baldwin, C.Y. and K. B. Clark	Capabilities and Capital Investment: New Perspectives on Capital Budgeting	Journal of Applied Corporate Finance (1)	General information on capital budgeting and the obtaining of future growth possibilities in the long run
2003	Barney, L.D. and H. White	Project-specific Financing and Interest Rate Risk in Capital Budgeting	The Engineering Economist (1)	Establishing duration as a measure of risk; increased when the time horizon grows (esp. interest rates)
2004	Brounen, D., A. de Jong, and K. Koedijk	Corporate Finance in Europe: Confronting Theory with Practice	Financial Management (2)	Background information on the most common traditional methods used in capital budgeting (Europe)
2013	Brunzell, T., Liljebloom, E. and M. Vaihekoski	Determinants of capital budgeting methods and hurdle rates in Nordic firms	Accounting and Finance (1)	Background information on the common methods used in the Nordics, setting of hurdle rate
1995	Busby, J. S., and C.G.C. Pitts	Investment and unpredictability: Why yardsticks mislead us	Management Accounting (2)	Pitfalls of the traditional methods in capital budgeting in conditions of uncertainty
2011	Chevalier-Roignant, B., Flath, C.M., Huchzermeier A. and L. Trigeorgis	Strategic Investment under Uncertainty: A Synthesis	European Journal of Operational Research (2)	Obtaining competitive advantage, first-mover advantages and disadvantages
2013	Chittenden, F. and M. Derregia	Uncertainty, Irreversibility and the Use of 'Rules of Thumb' in Capital Budgeting	The British Accounting Review (1)	Adjusting traditional methods in order to account for flexibility, firm-specific features, irreversibility and uncertainty
1977	Collins, F. and J. Willingham	Contingency Management Approach to Budgeting	Management Accounting (2)	Managerial success, personal accomplishment
1999	Cornell, B.	Risk, Duration and Capital Budgeting: New Evidence on Some Old Questions	The Journal of Business (1)	Duration as a measure of risk in capital budgeting; higher hurdle rates requirement

2009	Denison, C. A.	Real Options and Escalation of Commitment: A Behavioural Analysis of Capital Investment Decisions	The Accounting Review (3)	Escalation of commitment, pitfalls of traditional methods regarding assumptions on managerial behavior and organizational culture
1993	Dixit, A.K.	Choosing Among Alternative Discrete Investment Projects under Uncertainty	Economics Letters (1)	Value of waiting for new information, instability in prices and consumer demand, uncertain circumstances
1994	Dixit, A.K. and R.S. Pindyck	Investment Under Uncertainty	1 <sup>st</sup> edition, Princeton, New Jersey, Princeton University Press	Forms of flexibility, valuation of real options, limitations, effects of interest rates on capital budgeting
2004	Dreyer, B. and K. Grønhaug	Uncertainty, flexibility and sustained competitive advantage	Journal of Business Research (2)	Forms of flexibility (volume and value chain), importance of flexibility in uncertain circumstances
2002	Feinstein, S. P. and D.M. Lander	A Better Understanding of Why NPV Undervalues Managerial Flexibility	The Engineering Economist (1)	Valuation of flexibility, introduction of the WADR, shortcoming of traditional NPV and DCF methods
2002	Graham, J. R., and C. R. Harvey	How do CFOs make capital budgeting and capital structure decisions?	Journal of Applied Corporate Finance (1)	Shortcomings of traditional methods, constant capital structure assumption, most common methods used (US)
2016	Johannsen, B.K. and E. Mertens	The Expected Real Interest Rate in the Long Run: Time Series Evidence with the Effective Lower Bound	FEDS Notes, the US Federal Reserve	Background information on the current interest rate environment and its future development, predictions
2001	Kester, C.W.	<i>Today's Options for Tomorrow's Growth</i> , Real Options and Investment Under Uncertainty: Classical Readings and Recent Contributions	Cambridge (MA), London, England, The MIT Press	Effects of interest rate fluctuations, valuation of future growth opportunities obtained by the initial investment (real options)
2004	Keswani, A. and M.B. Shackleton	How Real Option Disinvestment Flexibility Augments Project NPV	European Journal of Operational Research	Increased project value with flexibility and disinvestment possibilities, exit options consideration
2010	Kort, P. M., Murto, P. and P. Grzegorz	Uncertainty and Stepwise Investment	European Journal of Operational Research (2)	Uncertainty regarding bulk versus stepwise investment



2001	Kulatilaka, N. and L. Trigeorgis	<i>The General Flexibility to Switch: Real Options Revisited</i> , Real Options and Investment Under Uncertainty: Classical Readings and Recent Contributions	Cambridge (MA), London, England, The MIT Press	Different forms of flexibility presented, limitations of added expenses to popularity and attractiveness
1998	Lander, D.M. and G.E. Pinches	Challenges to the Practical Implementation of Modeling and Valuing Real Options	The Quarterly Economic Review (1)	Limitations to flexibility, challenges of valuation methods and flexibility implementation
1985	McDonald, R.L. and D.R. Siegel	Investment and the Valuation of Firms When There is an Option to Shut Down	International Economic Review (2)	Forms of flexibility, option to shutdown operations
1991	Mukherjee, T. K.	Reducing the Uncertainty-Induced Bias in Capital Budgeting Decisions – a Hurdle Rate Approach	Journal of Business Finance and Accounting (2)	Setting of the hurdle rate, effects of duration and uncertainty in capital budgeting
2015	Roche, G.A.G., Lwango A. and G. Vuillemeys	Entrepreneurial Miscalculation and Business Cycles: How Interest Rate Targeting Distorts Capital Budgeting	Review of Political Economy (1)	Central banks' monetary policy regarding the current interest rate environment
2006	Smit, H.T.J. and L. Trigeorgis	Real Options and Games: Competition, Alliances and Other Application of Valuation and Strategy	Review of Financial Economics (1)	Deferring investment, growth possibilities, extended NPV approach to valuing flexibility
1996	Trigeorgis, L., 1996	Managerial Flexibility and Strategy in Resource Allocation	1 <sup>st</sup> edition, Cambridge (MA), MIT Press	Shortcomings and faulty assumptions of traditional capital budgeting methods
1998	Volberda, H.W.	Building the flexible firm – how to remain competitive	Oxford, Oxford University Press	Productivity in relation to flexibility