POSSIBILITIES FOR AN ENGINEERING CONSULTANT AS PROJECT DEVELOPER AND INVESTOR

PROBABILISTIC APPROACH TO AND THE VALUATION OF FLEXIBILITY OF A FULLY AUTOMATED CAR PARK

Msc Thesis Johan-Paul Verschuure
Faculty of civil engineering and Geosciences
Delft University of Technology
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TU Delft Technische Universiteit Delft

ROYAL HASKONING

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MSc Thesis Johan-Paul Verschuure
14th of November 2008

JP Verschuure
Graaf Florisstraat 108B
3021 CM Rotterdam
06 41254364
JPVerschuure@yahoo.com

Faculty of Civil Engineering and geosciences
Delft University of Technology
November 2008

Committee
TUDelft
Prof.drs.ir. J.K.Vrijling
Dr.ir. S.N. Jonkman
Ir.drs. J.G. Verlaan

Royal Haskoning
Ir. P.A.J.C. Kunst
Ir. C.P.W.J. Genders

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PREFACE

This is the report for my Master studies at the Delft University of Technology at the faculty Civil Engineering and Geosciences. This thesis is written with the department Hydraulic Engineering with the section Structural Hydraulic Engineering and Probabilistic Design. The research is done in cooperation with Royal Haskoning, Amsterdam.

This report discusses the contents of my graduation research. It includes theories used, a description of the model which was made and the results from the model applied on the case study. In the study the possibilities of developing and investing in civil engineering projects are central. The focus is on the project valuation, risks and business economics of the project. The report is set up of multiple parts:

Part I : Introduction and research scope
Part II: Project Valuation
Part III: Project Valuation Model
Part IV: Case study
Part V: Conclusions and recommendations

During my graduation research for my MSc studies I was assisted by my graduation committee. My committee consisted of prof. drs.ir. J.K. Vrijling, dr.ir. S.N. Jonkman, ir.drs. J.G. Verlaan, ir. P.A.J.C. Kunst and ir. C.P.W.J. Genders . I would like to thank them very much for their assistance.

Johan-Paul Verschuure

EXECUTIVE SUMMARY

The playing field of civil engineering has been changing the last couple of years, due to the introduction of Design, Build, Finance, Maintenance and Operate (DBFMO) tendering contracts. Private parties in the civil engineering, such as engineering consultants, face new challenges, opportunities and a changing field of interests. Especially the introduction of private financing opened up opportunities.

To research the possibilities of developing of and investing in civil engineering projects the conventional cost estimations should be extended with the financial side of the project. Since financial and market parameters influence the feasibility to a large extent (see Figure 2), opportunities can be identified by considering these parameters jointly with the technical parameters.

Real option valuation in civil engineering can be a useful addition on standard project valuation. This valuation method forces the identification of future decision points, values and maps project scenarios and facilitates possibilities to anticipate on changing project boundary conditions. Flexibility in a project's course, has significant value (see Figure 3), for example by identifying back-up scenarios. The real option valuation method that can be applied best is the valuation using decision trees. This method graphs possible project's courses and takes path dependency into account. The Black-Scholes model, which is used for the valuation of financial options, can not be applied for the valuation of real options. The underlying assumptions of the model do not hold for real options.

Engineering consultants can extent their activities as project developer and investor. Engineering consultants have expertise in assessing technical risk. They should focus on projects in which technical risk dominates. This can be done by focusing on projects with stable cash flows in the operational phase or forming alliances with market parties taking on the market and financial risk in the operational phase. Engineering consultants should focus on a sort of project in which they have a competitive advantage over other engineering consultants or in a market where there are few competitors. An indicator of these two aspects is the EBT-margin.

From the financial figures over the period 2005-2007 can be seen that engineering consultants and project developers have the highest margins. Over this period a movement is visible that these margins increased. The value added per employee is for the activity project development higher than of the engineering consultant.

In the case study presented in this thesis, the possibilities of developing of and investing in a fully automated car park are investigated. The 3 storey car park is located in Amsterdam in the city part Oud-Zuid underneath the Boerenwetering. The case study is studied using a financial model in which the technical project aspects are combined with the financial aspects. Based on the results from a Monte Carlo simulation the feasibility and sensitivity of the project can be assessed.

The 3 storey car park has a length of 263 m and a width of 13,6 m. The foundation of the car park is 9m underneath the bottom of the canal, which lies at 3,4m – NAP. In the car park 460 fully automated parking spaces will be realized, of which 75% will be used for short term parking and 25% for licensed parking. The parking fare for short term parking in this part of Amsterdam is 3,80 €/h. The determined average occupation rate of the short term parking spaces is 35%. The licenses offered are a full license, night license and office license costing respectively €2500, €1200 and €1800 per year.

The development of the car park is an interesting investment opportunity. The construction costs will add up to approximately 33,7 Mio € and the construction has an expected duration of 157 weeks. With the simulation a Net Present Value of the project of 5.010 k€ is obtained. In the model a Weighted Average Cost of Capital (WACC) of 8,5% is used. The probability of a positive NPV is 76%. The internal rate of return (IRR) is on average 11,1%. The 95% exceeding level is an IRR of 5%. The IRR of a 4 storey car park is 11,6% and therefore expected to be more profitable. The options of changing exploitation and developing a second similar car park have significant value.

SUMMARY

The playing field of civil engineering has been changing the last couple of years, due to the introduction of Design, Build, Finance, Maintenance and Operate (DBFMO) tendering contracts. With the introduction of the Public Private Partnerships (PPP) the public sector shifted responsibilities in the development of civil engineering projects towards the private sector. Private parties in civil engineering, such as engineering consultants, face new challenges, opportunities and a changing field of interests. Especially the introduction of private financing opened up opportunities.
One of the new opportunities engineering consultants face is the opportunity of taking on an active role as project developer and investor in civil engineering projects. For engineering consultants backwards integration in the civil engineering value chain can raise opportunities:

- The product of an engineering consultant gains credibility.
- Active participation in the risk can be a competitive strength in forming joint ventures.
- Expertise and contacts can be commercialized.
- Possibilities to push projects on the market. Through technical insight and know-how the feasibility and profitability can be better assessed.
- The employees are challenged to come up with creative and innovative ideas for own commercialization and can accumulate financial and commercial knowledge.

Taking active part in the risk of a project means that the engineering consultant needs to extend his position from the traditional role of technical advisor to the position of equity investor and project manager. However the view on a project by an engineering consultant is totally different from the view by an investor. In this thesis both points of view are investigated to get insight into how they can be combined best. The study focuses on the risk in the projects, the valuation of projects and the position in the value chain. This is done by:

- Assessing the risks in developing a project seen from both points of view and clarifying how they relate to each other.
- Combining the valuation methods from the two points of view.
- Adding a study on how flexibility can be valued in civil engineering projects.
- Placing this all in the context of the civil engineering market with a study of the market situation and movements in the civil engineering value chain.

The first three bullet points are discussed by developing a financial model of a case study on developing of and investing in fully automated car parks underneath the canals in Amsterdam.

Project risk

In civil engineering projects operational and market risks can be identified. Operational risk can be divided in the technical risk of the construction and the financial risk related to the financial parameters in exploitation and financing of the project. The market risk covers the external financial risk, such as interest rate changes and changes in rate of inflation.

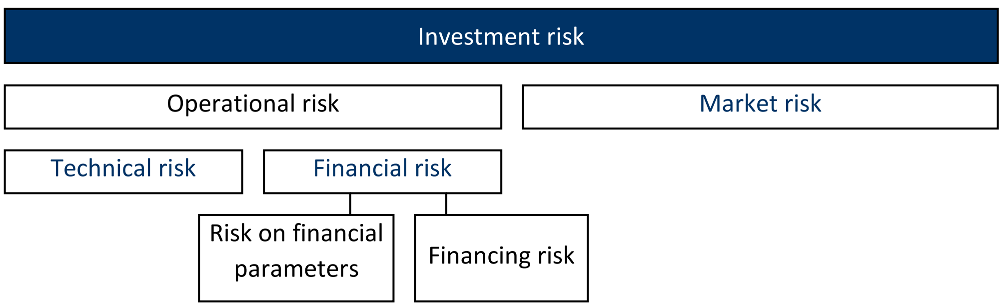


Figure 1 Qualitative relation between risks in civil engineering projects

Technical risk is included in the valuation using a probabilistic cost estimation and a separate technical risk analysis. Financial risk can be divided into uncertainty on financial parameters and the financing risk. The financing risk is the risk of insolvency of the financing reservation and the risk of insolvency of the debt service. The risk of insolvency of debt service is assessed using a number of ratios: the Debt Service Cover ratio, the Loan Life Cover ratio and the Project Life Cover ratio.
Market risk covers the risk of changes in the market interest rate and the rate of inflation. In project financing these risks are generally taken over by the bank. The exposure to market risk is given by the parameter beta in the CAPM-model. For project developers and investors this beta is lower than that of engineering consultants, meaning a lower exposure to market risk. The beta of the engineering consultants is again lower than that of construction companies.

A model is proposed to value a project incorporating risk and uncertainty of both the technical and financial side of a project. From analysis applying this model on the case study the relations between the risks in the development and exploitation of a civil engineering project is investigated. This risk is defined as the variations in the assumed mean expected values. It can be seen from Figure 2 that in this case the financial risk causes the largest distribution of the Internal Rate of Return. The variation in outcome due to market risk is a little bit higher than the variation due to technical risks during construction.

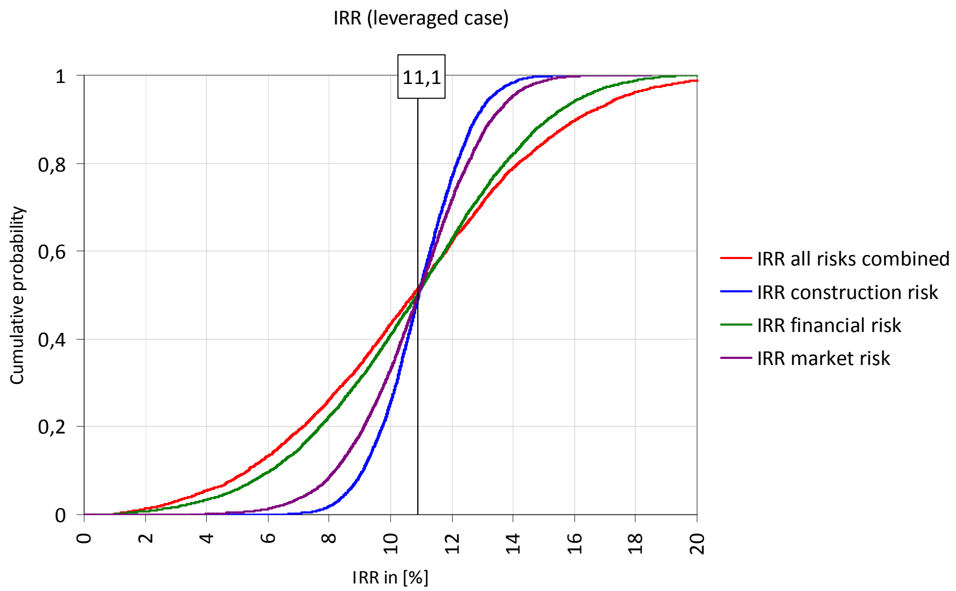


Figure 2 Distributions of IRR for different risk groups

Valuation and valuation of flexibility

To study the possibilities of developing and investing in civil engineering projects conventional cost estimations should be extended with valuations of the financial side of the project. Considering financing costs and optimizing these costs can cause considerable savings. Taking the financing of a project into account can improve the profitability significantly.
Extended NPV methods can then be useful in civil engineering in order to be able to take flexibility in the design and use into account in the valuation. This can be useful because flexibility has significant value in civil engineering projects due to long project durations, technical complexity and the large influence of the boundary conditions. The option to react on the changing boundary conditions is called a real option. Real option valuation is useful because it:

- Forces identification of future decision points
- Identifies, values and maps project scenarios
- Facilitates possibilities to anticipate on changing project boundary conditions and can help identifying opportunities that may arise from these changes.

In theory three methods of real option valuation are described:

- The Black and Scholes model for the valuation of financial options
- Binomial (or multinomial) Tree Analysis
- Decision Tree Analysis and Influence diagrams

The Black and Scholes model can not be applied directly on real options in civil engineering since the underlying assumptions of the model do not hold for civil engineering projects. However the theory of the financial options can help to identify and analyze options in real projects.

The binomial tree is a useful approach for projects in which clear phasing and uncertainty of continuation of the project are characteristics of the project and path dependencies are not important. For these reasons it is less applicable to civil engineering projects.

Decision tree analysis can be applied well in civil engineering projects. It is useful because it forces to map decisions points in the project's course, can value and graphically show decision scenarios and includes path dependencies.

The application of decision tree valuation and the binomial tree valuation including the option of changing the exploitation of the car park, shows significant value (see Figure 3). In this option the exploitation is changed if the exploitation success of the car park is poor. Decision tree analysis shows the largest shift of the cumulative probability distribution because path dependency can be better taken into account in the project valuation.

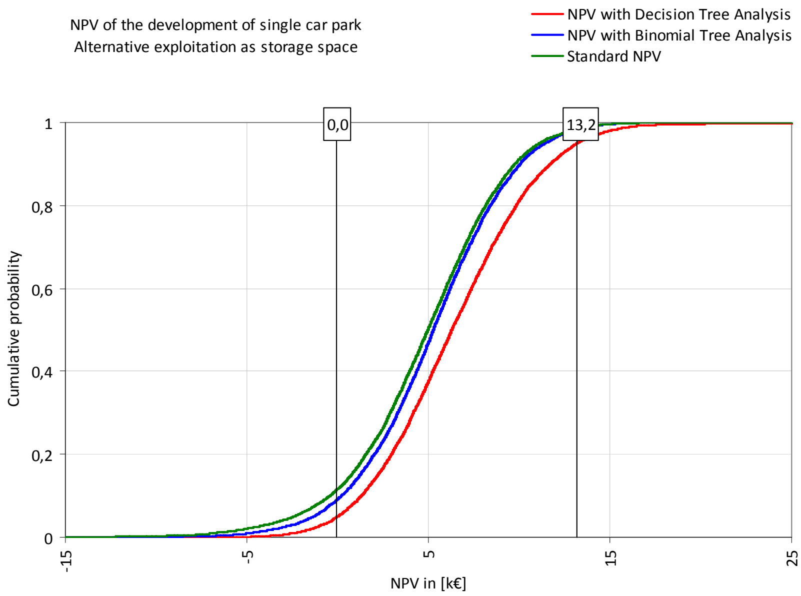


Figure 3 NPV of the development of single car park including the option of alternative exploitation

Value Chain Analysis in civil engineering

To investigate the positioning in the value chain and where a company can make the best profit and make most profit from its employee's expertise, a short value chain analysis can be used giving insight in the market situation, the movements and context of this study. The value chain of a civil engineering project is divided into the activities: Engineering services, project development, (utility) construction, infrastructure and operation. These activities cover the responsibilities incorporated in a DBFMO-project.

A project developer and an engineering consultant have on average the highest profit-margins in the value chain, as is shown in Figure 4. A project developer has a higher margin than an engineering consultant. Over the last three years the profit margins in construction and operation got smaller. The margins of project developers and engineering consultants got larger.

The added value per employee is for a project developer higher than of one in engineering services. The added value per employee in construction, infrastructure or exploitation is considerably lower. The added value of an employee in project development and engineering services has increased over the last three years.

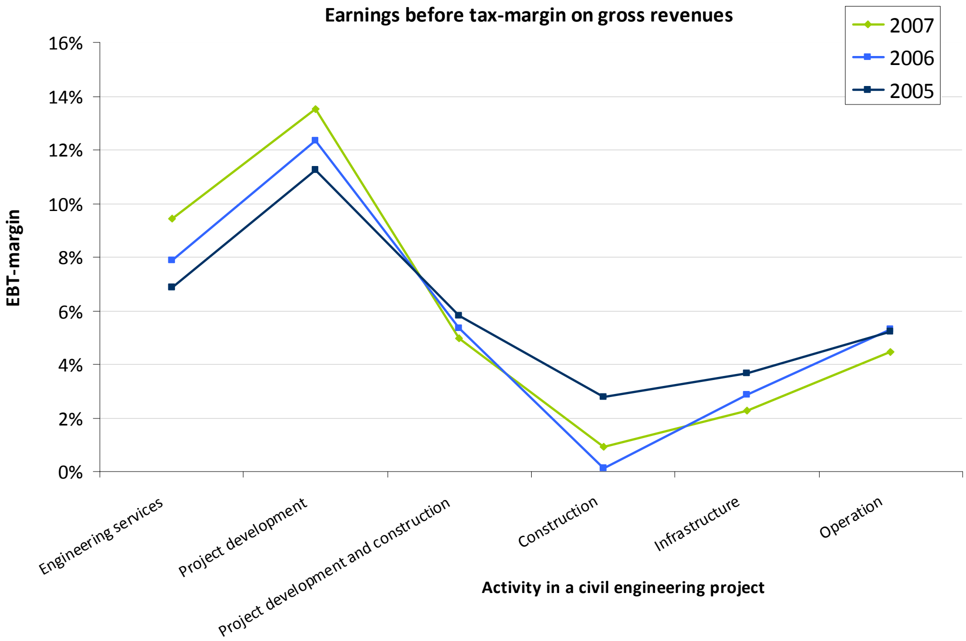


Figure 4 Earnings before tax margin on gross revenue per activity in the civil engineering value chain

SUMMARY OF RESULTS OF CASE STUDY

The car park in this case study is located in Amsterdam in the city part Oud-Zuid underneath the Boerenwetering. The 3 storey car park has a length of 263 m and a width of 13,6 m. The foundation of the car park is 9m underneath the bottom of the canal, which lies at 3,4m – NAP. In the car park 460 fully automated parking spaces will be realized, of which 75% will be used for short term parking and 25% for licensed parking. The parking fare for short term parking in this part of Amsterdam is 3,80 €/h. The determined average occupation rate of the short term parking spaces is 35%. The licenses offered are a full license, night license and office license costing respectively €2500, €1200 and €1800 per year.

The case study of a 3 storey fully automated car park is studied using a financial model in which the technical project aspects are combined with the financial aspects. Based on the results from a Monte Carlo simulation the feasibility and sensitivity of the project can be assessed.

It follows from the results that the Net Present Value of the project is 5.010 k€. In the model a Weighted Average Cost of Capital (WACC) of 8,5% is used. The probability of a positive NPV is 76%. The internal rate of return (IRR) is on average 11,1%. The 95% exceeding level is an IRR of 5%. In comparison to the average return on other infrastructure investments, the mean expected IRR is a couple of percent lower. In comparison to standard real estate investments the IRR is slightly higher. The construction costs will add up to approximately 33,7 Mio € and the construction has an expected duration of 157 weeks.

It follows from the sensitivity analysis that the parameters with the largest impact on the profitability of the car park are mainly financial and market risk parameters. The uncertainty in occupation rate, parking fare and the reluctance of people using the car park are the largest risks for the development of the car park. Interest rate and rate of inflation are not considered since these risks are generally taken over by the bank. The largest technical risks are the thickness of the walls, steel prices and mistakes due to wrong assumptions. Another risk in the design is the number of free parking spaces needed to be able to maneuver with the fully automated car park system. In the model it is assumed that one parking space per 16 is required to be left free for the mobility of the system. Each additional space required for mobility per 32 spaces, reduces the NPV of the project by 1 Mio€.

Developing a car park with 4 storeys is more profitable over the life time than a car park with 3 storeys. In the 4 storey car park 610 parking spaces will be realized. Although the cumulative discounted construction costs increase from 33,7 Mio € to 37,5 Mio €, the IRR increases from 11,1 % to 11,6%. The NPV of the 4 storey car park is 7,5 Mio€. In the increased construction costs the increase of costs for sheet piling, strutting, material costs and an additional risk reserve for geotechnical problems of 2,5 Mio€ are included. In this case the construction is expected to take 197 weeks.

The option of changing to an alternative exploitation and the development of multiple car parks has a significant added value and should be taken into account. The option of switching to a self storage exploitation in case the exploitation as a car park is not successful is expected to have an average value of over 1 Mio €. The value of developing a second car park 1,5 year after the start of the first car park has an average value of around 100k€. This case represent the situation no exclusive right on the development can be obtained. In the case risks in the first phase can be shifted further to the future, this value can increase even more. If an exclusive right of developing a second car park can be obtained, the value of developing a second car park has a high value.

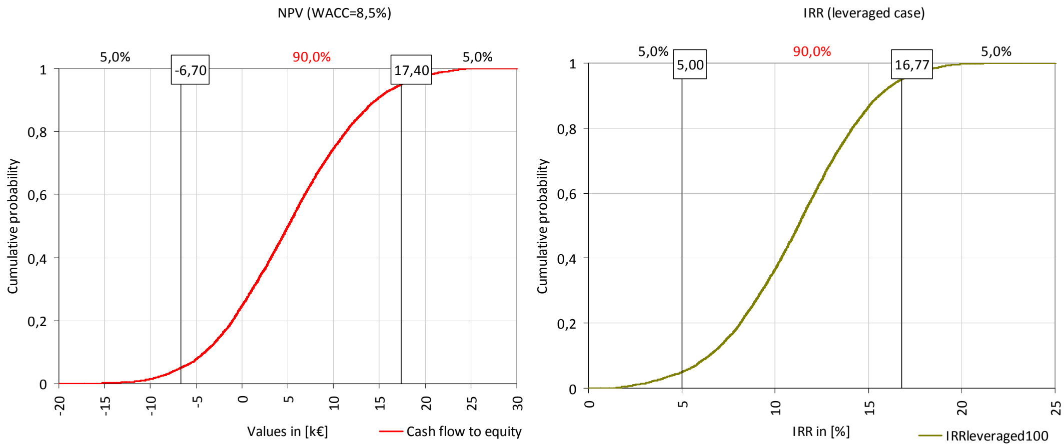


Figure 5 Distribution of IRR and NPV of developing a 3 storey fully automated car park

To research the possibilities of developing of and investing in civil engineering projects the conventional cost estimations should be extended with the financial side of the project. Since financial and market parameters influence the feasibility to a large extent (see Figure 2), opportunities can be identified by considering these parameters next to the technical parameters.
Real option valuation, by means of valuation with the decision tree analysis, can be a useful addition on standard project valuation in civil engineering. This valuation method forces the identification of future decision points, values and maps project scenarios and facilitates possibilities to anticipate on changing project boundary conditions. Flexibility in a project's course, for example by identifying back-up scenarios, has significant value.

PART I: INTRODUCTION AND RESEARCH SCOPE

The playing field of civil engineering has been changing for the last couple of years, due to the introduction of Design, Build, Finance, Maintenance and Operate tendering contracts. This results in new possibilities for players in the field of civil engineering. Engineering consultants like Royal Haskoning face this new playing field. This offers new challenges, opportunities and fields of interests. One of these new fields is translating civil engineering risk optimally into a finance structure. In this part the playing field in civil engineering is central. In the second chapter the research scope is described.

1. INTRODUCTION

The tendering process of large civil engineering projects has changed over the last couple of years. In the traditional way of tendering the public sector was project owner, taking on the responsibility of the project management. The design, exploitation and financing of the project rested with the public sector. The construction was done by private contractors (see
figure 6).

In the late 1990's the Dutch government decided to implement Public Private Partnerships (PPP) for large civil engineering projects. With these PPP projects the responsibilities of the project management were shifted towards the private sector. In 2005 the Dutch government decided to structurally implement the new PPP form of Design, Build, Finance, Maintenance and Operate contracts (DBFMO-contracts). The public sector kept the role as project owner and initiator. However the responsibilities of the design, financing and maintenance during the exploitation phase were mandated towards the private sector (see
figure 6).The standard contractor now has to take care of more facets of the project. It has to take on a role as project developer instead of the traditional construction company.

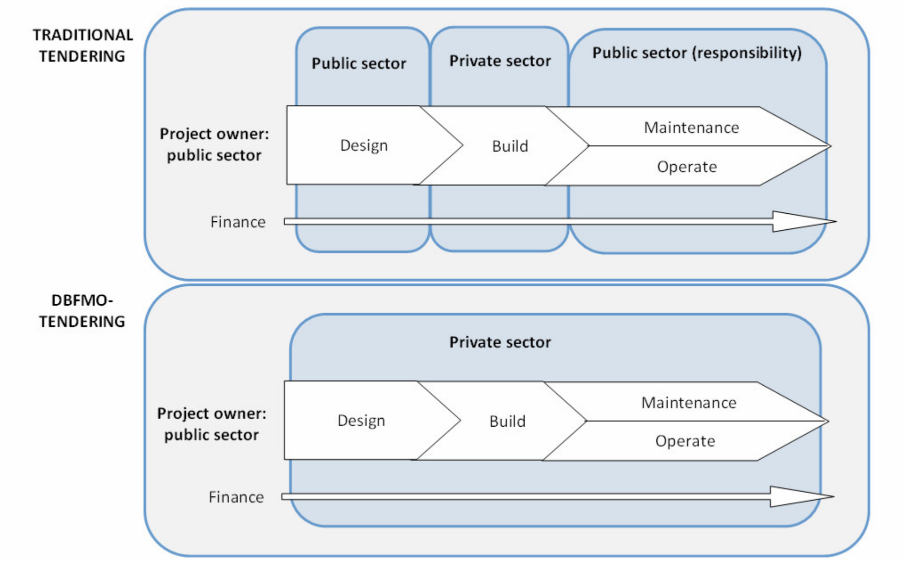


Figure 6 Overview executioner of each part of a project in traditional tendering and with DBFMO contracts

The advantages of the PPPs lie in the integration of the different project responsibilities with private parties. Private parties are believed to execute project more effectively and efficiently. Another reason is the introduction of market mechanisms in a traditional public sector. Players on the civil engineering playing field can take on an active role as project developer. They are not bounded by the traditional role in the project process. Engineering consultants can try to commercialize their technical and project management knowledge. Royal Haskoning is interested to take responsibility for a larger part of the project and investigate the possibilities to develop and invest in their own projects.

With these new responsibilities and opportunities, new challenges arise. In order to asses the possibilities of investing and developing projects actively, three important aspects can be identified:

- Accurate project valuation including project uncertainties and flexibility
- Optimal translation of project risk into a profitable investment and the relation between different risks (technical risk, financial risk and market risk)
- Identifying criteria for identifying profitable civil engineering projects

These three aspects are crucial in winning projects and securing profitability for any party wanting to act as investor and project developer.

This MSc. thesis focuses on how technical risk, financial and market risk can jointly be translated optimally into a project valuation and financing structure. Main questions are how project uncertainty and flexibility can be valued and financed. The research is applied on a case of Royal Haskoning. Royal Haskoning is interested in developing and investing in car parks underneath the canals in Amsterdam.

In part I of this thesis the introduction and project scope is given. After this introduction (chapter 1) a more detailed description of the problem situation is given (chapter 2). In this description the market situation and the basic concepts are presented. This part is concluded with the research scope (chapter 3) describing the problem definition, research goal and model.
Part II deals with the theories of project valuation. In this part the theory of project valuation from corporate finance (chapter 4) and the theory of project valuation applied in civil engineering (chapter 5) are discussed. Next the risk analyses from a technical and financial point of view are central (chapter 6). This part is closed with the theory of how to valuate flexibility with the real option theory (chapter 7).
The valuation model and the valuation of flexibility is discussed in Part III. Chapter 8 describes the model that is made for this research. In this chapter the cases which are investigated using real option valuation are described. The second chapter (chapter 9) covers the practical application of the valuation of flexibility.
In part IV the case study is described. The chapter is started with the general description of the fully automated car park (chapter 10). This chapter is followed by the results from the model and the comparison of the different risks in this case study (chapter 11). The results of the different valuation methods incorporating the valuation of flexibility are described next (chapter 12). This part is concluded with the context of a value chain analysis (chapter 14).
The final part and final chapter covers the conclusions and recommendations.

2. PROBLEM SITUATION

"On the infrastructure market especially parties are seen which are interested in building and constructing. Financing and developing integrated solutions gets too little attention."[32

2.1. Introduction

The playing field of civil engineering has been changing for the last couple of years, due to the introduction of Design, Build, Finance, Maintenance and Operate (DBFMO) tendering contracts. New responsibilities were rested with the private sector. In this chapter the most important changes in the playing field are described. In section 2.2 the shift from traditional to innovative contracts is described. In the next section (section 2.3) the most frequent used innovative contract, the DBFMO contract is described. One of the most important new responsibilities for the private sector is financing of infrastructural projects, which is central in section 2.4. The chapter is concluded in section 2.5 with a brief general discussion on the changing playing field in civil engineering in the Netherlands.

2.2 Traditional and innovative contracts

In the late 1990s the traditional way of tendering large civil engineering projects was replaced by a new innovative contract. In the traditional way of tendering the responsibility of initiative and execution of a project was nested with the public sector. The public sector made a design. Contractors were able to bid on the realization of the design. The contractor with the lowest bid was given the project. Payment of the contractor was based on realization of the project. Responsibility for the finance, maintenance and operation was at the public side (see
Figure 7).

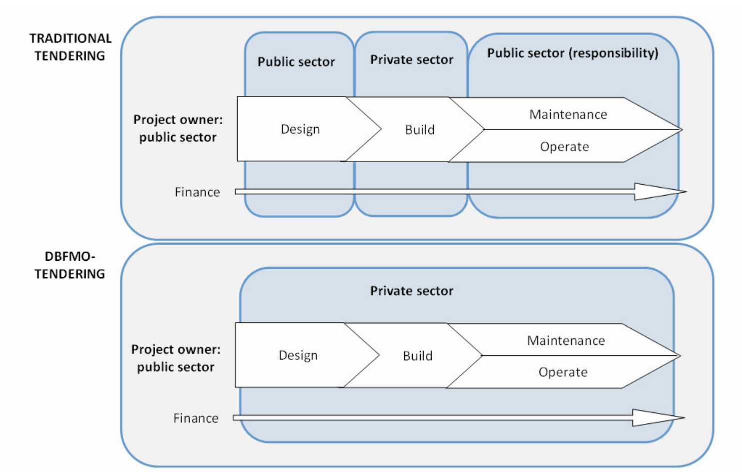


Figure 7 Overview executioner of each part of a project in traditional tendering and with DBFMO contracts

In the new innovative contract forms, the public sector started to outsource responsibilities towards the private sector. This resulted in Public Private Partnerships (PPP)(Dutch: Publiek Private Samenwerking (PPS)). Design & Construct contracts were the earliest PPP structures implemented in the Netherlands in the late 1990s [42. By this form both the responsibility of the design and construction phase was given to the contractor. Since 2005 the Dutch government decided to structurally extent the number of responsibilities outsourced. For all large civil engineering constructions a new innovative contract was implemented[43: The Design, Build, Finance, Mainatenance and Operate contract (DBFMO-contract). This DBFMO-contract replaced the traditional tendering and Design & Construct contracts. By this structural implementation PPP-project are expected to increase in number and will be the new standard in the next years [13.

In this new contract the public sector not only outsources the design and construction (DB) of the project, but as well the financing, maintenance and operation (FMO) (see Figure 7). From this point on the Dutch government is legally obliged to test whether each new project can be tendered by a PPP-contract form: the Design, Build, Finance, Maintain and Operate contract (DBFMO-contract).

In the DBFMO-tendering the public sector takes the initiative of developing a new project. As project owner they functionally specify their wishes of the construction to be realized. The private parties have to indicate how they think to optimally fulfill the functional wishes. An effective and efficient solution should be achieved by integrating the different responsibilities and project phases in one party. The contractor therefore has to include the expertise of the different responsibility areas in a project company. The company with the lowest bid is given the project. In the bidding procedure high quality and extra functionalities can be included in the valuation. This is done by stating these criteria and valuation methods in the project description. The bidding phase is done in an active dialogue between project owner and contractor about functionality and feasibility. This should result in a maximization of the total economic and social value.

2.3 DBFMO[1]-contracts

'Innovative' contracts such as DBFMO-contracts have been around in the United Kingdom since 1992 and now are increasingly important on the Dutch market. The innovative part of this cooperation lies especially in the "F" of Finance. By letting the private partner taking on the finance part of the work, it forces the project taker to think of an economic effective and efficient solution on the long run. This is done in multiple ways.

2.3.1. How does DBFMO work?

By a DBFMO contract the government uses functional specification to describe the output that is desired: number of offices, number parking spaces, availability etc. This shift from input oriented to output oriented leaves space for creativity for private parties to come up with solutions how the required output can be realized best. The incentives to stimulate the private parties to meet the requirements and create creative solutions are implemented by the structure of tendering and payments.

The payment the private part receives for the project is linked to the daily performance of the structure. Instead of paying on delivery of the structure the construction costs, the government forces the project company to meet the preset requirements as frequently as possible. The payments are split between an availability payment and a payment per use (see Figure 8). The payments for a

[1] In general DBFMO is mainly used in governmental housing, since the "O" of operation can contribute significantly to the total project costs. However in infrastructure generally the O is omitted since the contribution here is less. In principal DBFM and DBFMO are the same project types.

structure are spread out over the total life cycle of the structure. This way there is an imbalance between the costs of construction in the beginning of the project and the benefits that are raised when the structure is in place. This gap has to be crossed by the private parties to finance the project itself. By outsourcing the financing the project, the public sector has a mean to push the private sector to meet the output requirements and try to finish the project as soon as possible.

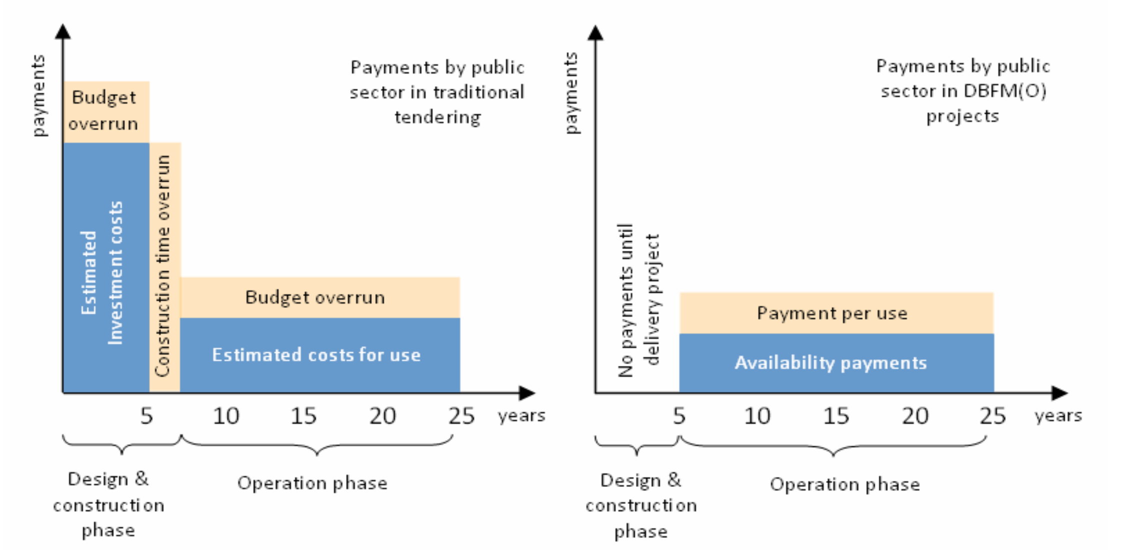


Figure 8 Comparison of payment made by public sector in traditional tendering and DBFM(O) project

Secondly, by the tendering structure the government introduces competition between the participants in the tendering phase. Multiple project companies are invited to take part in the tendering. The government selects a preferred bidder on a combination of cost and quality. In special cases other criteria can be used to offer the project to a bidder [17. If the bid of one project company is not competitive enough, the company does not receive the offer. This is in line with the goal to increase the effectiveness and efficiency of the Dutch public investments[38.

The third main advantage of this contract form is that costs for the public sector stay limited to the bid sum (excl. claims that may arise and additional work). The costs due to risks and unforeseen events are hedged largely towards the private parties. The expectation is that the project company can manage these risks and unforeseen events better than the public party. By identifying risks, pricing of the risks and allocation of the risks to responsible parties an effort is being made to control the unforeseen costs over the projects duration. By doing so, the government faces less budget overruns as were common in the traditional tendering. For private parties the risk-management is important to secure the profitability of each project.

2.3.2. Stakeholders DBFMO

The organization of the stakeholders in a DBFMO project is shown in figure 9. The Special Purpose Vehicle (SPV) or Special Purpose Company (SPC) is founded to take on the central role as general contractor. This SPV is founded as a clean party, not having any obligations or responsibilities from prior activities. In the SPV several companies can take place forming a consortium. The SPV is the central player in the project communicating with all the other stakeholders (see Figure 9). The SPV can be seen as a private project developer, however without taking the first initiative of pushing a project on the market. This role of initiating projects stays with the public sector and its planning policy.

The SPV is responsible for the project management. They take on the long term agreement with the public sector with the tender contract. Since the benefits of the output payments occur in a later phase than the cost, they have to finance the project with both equity and debt. For this financing the

SPV forms contracts with equity firms, debt investors and other financials (such as banks). Various structures for the financing of large constructions are possible on the market.
On the other hand the SPV has the responsibility of coordinating the design, construction and the services required in operation phase. This is generally done by hiring a number of subcontractors. The traditional role of an engineering consultant is in this part. Most of the time the advice is in the design part of the project.

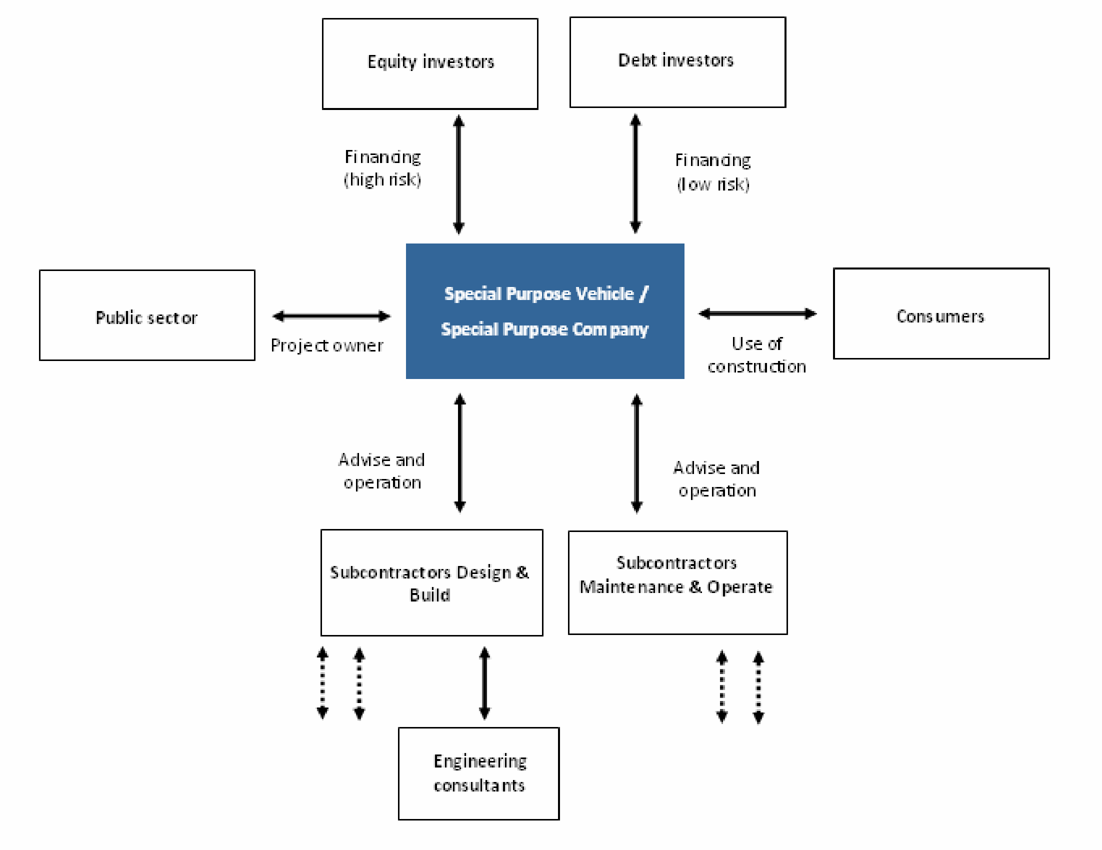


Figure 9 Stakeholders and their participation in DBFMO tendering

The SPV can have interaction directly with the customers itself. This depends on the contract form and the type of construction considered. For example, if the service payments are only based on availability of the road, the customer only uses the road and having little interaction with the SPV. However, if it is decided that the road is a toll road or a road with additional customer services, customer interaction is present.

2.3.3. Actual tendency towards DBFMO

Although the DBFMO contracts are widely celebrated as a good way to introduce the market effectiveness and efficiency to the public works, many problems have been raised in the last few years. At the moment the largest complaint by the private sector is that too few projects are tendered using a DBFMO contract [11[12[15[18]. Although many private stakeholders seem to be interested in PPP-projects, few PPC[2] show suitable projects for PPP tendering. Some stakeholders state that including the financing prevents smaller projects to be tendered via PPPs as well [9.
Secondly the tendering structure leads to problems and according to many parties to suboptimal solutions. The fierce competition between the tendering parties can lead to problems for contractors. In the preparation phase high costs are made for feasibility studies. If in later stages projects are not won successively by a contractor this can lead to financial instability of the contractor. According to

[2] Public-Private Comparator (PPC) is a rough instrument to compare the additional value of a PPP-structure to traditional tendering in an early phase

the private side, the redemption for the calculation costs is too little to take risks when competing to win the bid [14]. The costs of the feasibility studies and preliminary design will be calculated to the government in any case, contractors advocate. Next to this the selection is generally made only on costs and quality. A broader perspective of the value-for-money offered by a project is advocated [17]. This should be incorporated more in the project specific contracts. However problem with leaking knowledge on the public side, lack of trust of both sides [16] and too little experience with contracts on the private side [10] , prevent the contracts to be executed in a right way.

2.4. Finance in infrastructure and real estate

As described the "F" of finance in projects has the largest impact on the construction sector. The bridge between the design and construction on the one side and the benefits and opportunities raised by exploiting is relatively new to the traditional parties. Therefore a shift in attention towards the interaction of the SPV and the financial stakeholders is currently perceived.

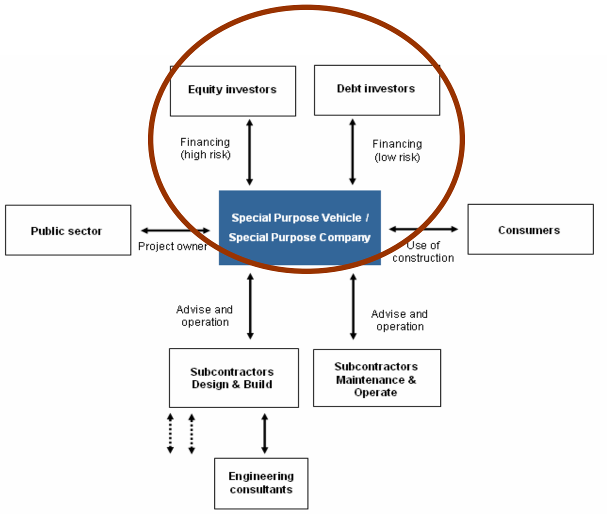


Figure 10 Stakeholders in financing in infrastructure and real estate

2.4.1. Financing mix in DBFMO

Financing infrastructural and other civil engineering works can be done by using a mix of finance components. The finance mix varies for each project, depending on the project's characteristics. Most important criteria for the chosen finance structure are the expected cash flows which are also determined by contracts and the risk involved with the construction and exploitation of the structure. With financial engineering a mix can be made optimized for each project. Based on [39] the situation of project finance with DBFMO contracts is described.

For financing a project both equity and debt are used. The difference between these lie in the risk on the investment and the return associated with the risk. Financial components commonly used in DBFMO projects are:

- Public finance

  This financial instrument carries the lowest risk and therefore the lowest return. Since the risk of a bankrupt government is very low, financing by issuing government bonds yields low returns. Example of this instrument is financing by the government or by the European Central Bank.
- Equity.

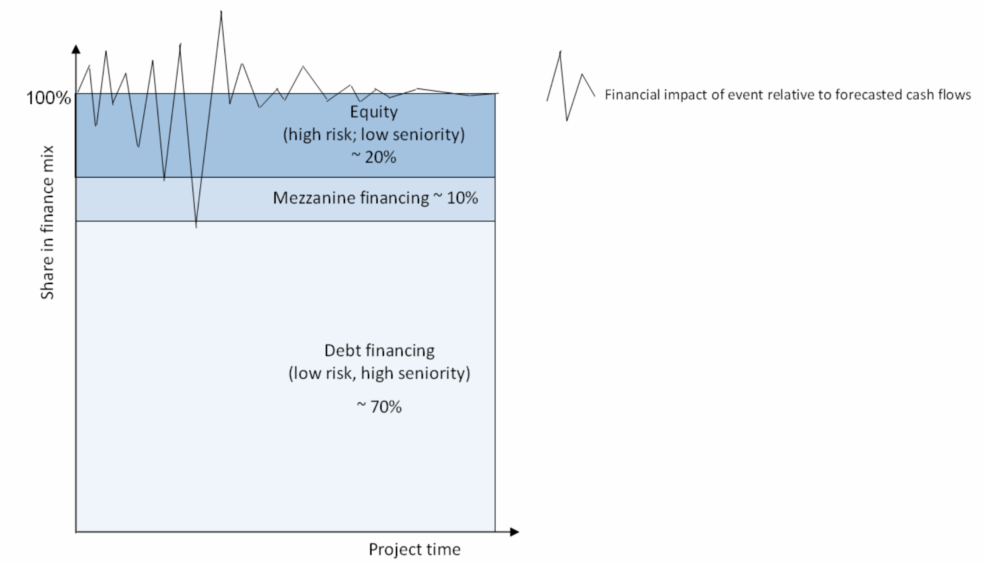
  Equity is brought in by the risk taking parties organized in the SPV. Equity holds the largest risk. If a project files for bankruptcy, the equity are the last in line to claim money back (the least seniority). Therefore equity requires the highest return. The return is called Return On Invested Capital (ROIC)
- Commercial loans

  Commercial loans are generally given by banks. On the loans interest has to be paid. Loans have the highest seniority. This means that on default the debt investor has the highest priority to get money back. Money earned by the exploitation of the project is first going to the most senior party.
- Mezzanine finance

  This financial mean lies in between the equity and commercial loans regarding risk and return. Mezzanine finance is generally used as short term financing by banks. Because of the short term character there is no extensive due diligence executed. This results in a higher required return on the loan.

The shares of all the financial components in the financing structure depend on the characteristics of the project. Two balancing forces act to determine the structure. For example the amount of equity needed in a project depends on two factors:

Risk associated with the project. The higher the risk the larger share of equity required by other financials. However the SPV wants to reduce their share of equity in order to increase the profit (this is called the financial leverage). If the risk is stated as the volatility of the projects expected return (Figure



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- Figure 11, line) , higher risk causes that there is a higher chance that unforeseen event or risk affect the part financed
- Commitment required by the SPV. The larger the share of equity, the higher the incentive for the equity contributing parties is to complete the project successfully. The SPV however would want to limit the share of equity to maximize their return on investment.

In Figure 11 a possible financing structure is shown. The percentages of the financial components are common numbers in practice. These percentages can deviate from the ones shown, based on the individual project and the risks involved. For very low-risk projects the equity-debt ratio can reach up to 10% : 90% for infrastructure projects. In private real estate this tends towards 35%:65%.

The expected return of the project is shown in the bottom of the graph. The line depicts the financial impact of a risk in comparison to the budgeted risk. If the line is above the project-time axis this means that such an amount of money is needed to cover the risks at that moment. If an additional amount of money is needed for an unbudgeted event, the expected return of the project decreases. This line shows two features:

- If an event with a high financial impact happens, the equity share is first to cover the risk (lowest seniority). If this is not sufficient the second portion which is at risk is the mezzanine finance. The portion which is debt financed has the highest seniority.
- In the course of the project the fluctuations of the impact decrease. If lower risk is experienced or expected, recapitalization can take place. Recapitalization means a change in the percentages of the financial components. Lower risk in a certain project phase can lead to a decreased portion of equity required. This leads to a cheaper financing structure.

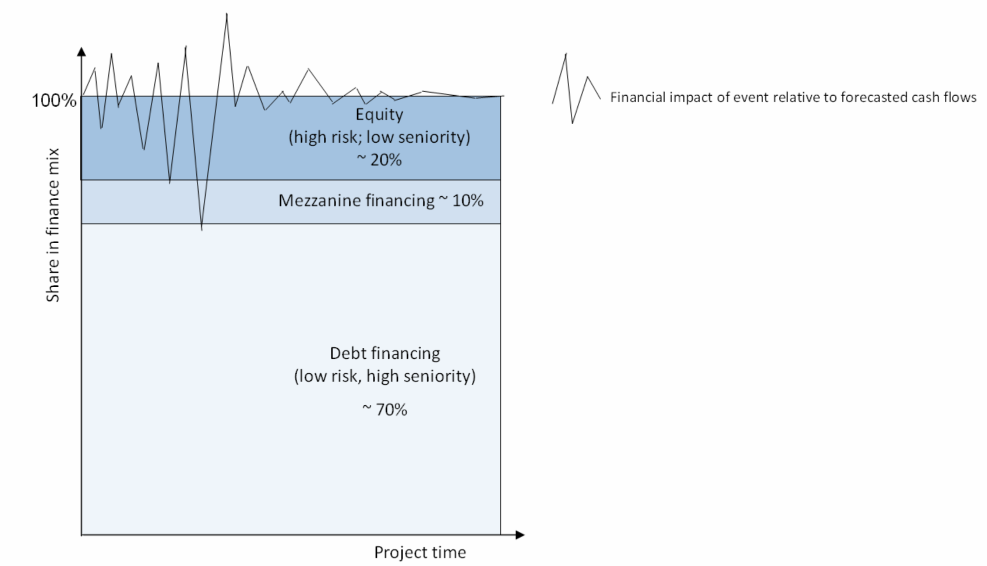

Figure 11 Possible financing structure for infrastructural or real estate project. The financial impact of the project relative to the forecasted cash flows is schematized with the line. Events above the 100% line are beneficial to the equity share. Events with a negative financial impact are first taken by the equity. After equity the mezzanine finance is affected first. As last portion the debt financing is endangered by a negative financial impact.

2.4.2. Actual situation of project finance in DBFMO

Determination of the financing structure and the costs of financing depend on the underlying technical project. Both the uncertainties and risks in the construction phase and in exploitation phase determine the financing structure and required return on investment by all parties. Therefore a link exists between the technical risk incorporated in the design and the costs of financing the structure its lifecycle.

The required return is mainly determined based on experience, since financials have limited insight in the technical uncertainties and risks. The budgeted premium for technical risk is estimated based on the advice of the SPV. The financials hire external experts to check whether the risk analysis is correct [39[40. Next to these risks, financials included financial risk in their calculations. The risks faced by financials are described in the Basel II-accords [1]. To reduce the risk for a financial institution, the risk is hedged towards multiple banks by derivative products[3]. Each institution buying such a derivative takes on a part of the total risk. The prices banks are willing to pay for a part of the risk depend on project risk estimations and consensus of the banks on the project. The two most important criteria here are market perception and boundaries set by the agreement between the SPV and the financial parties. In general financial institutions are very interested in financing in infrastructure and real estate. The (relatively) low risk profile of projects give offers possibilities to invest in. Especially in the light of the current credit situation financials are willing to invest in fixed assets [30.

On the other hand traditional civil engineering companies have little insight in the methods used by the financial partners. As well construction companies are not familiar with the possibilities that lie in projects. Both possibilities from the market side of the project and the finance side are generally underestimated. The communication between the SPV and the financial institution is based on experience numbers and is static. The link between the financing structure and the technical risk has been blurred.

[3] Based on conversations with bankers in infrastructural and real estate finance

2.5. Changing playing field of civil engineering

The playing field in civil engineering has been changing due to the privitization of the execution of projects. Two major driving forces that are changing the playing field are:

- an increase in Public Private Partnerships
- changing role of the contractor

2.5.1. Increase in Public Private Partnerships

The number of PPP projects is expected to grow with the legal obligation to investigate the feasibility of a DBFMO contract for large civil engineering projects [43. Next to this positive experiences with DBFMO tendering cause an expected increase in projects. These early experiences show less cost overruns and less exceeding of plannings[12. Tendering of PPP projects can lead to an additional value advantage of 5% – 20% in comparison to the traditional way of tendering [38. According to project director of the first Dutch DBFMO-contract of the N31 the additional value even reaches 30% - 40% [12. In table 1 an overview is given for the first couple of realized DBFMO contracts in the Netherlands. Realized savings have even been higher than budgeted by the government in the PPC3 and PSC4. It has increased the value for money of the projects (De Ridder, 2002, [49]).

PP-project	Contract	Maintenance	Budgeted savings	Realized savings
Montaigne	DBFM	28,5 year	9% (PPC)[4] - 16% (PSC)[5]	16%
A59	DBFM	15 year	14%	< 14%
N31	DBFM	15 year	5%	30%
Harnaschpolder	DBFO	30 year	10,5%	Ca 17%

Table 1 Overview of budgeted and realized savings on DBFM projects [12] [38] [45]

Next to PPPs, private investments in fixed assets show an increase as well [54]. These include private real estate projects, smaller private projects and construction works for larger companies. For private customers a shift towards offering an integrated technical solution for satisfying a need is even more important (de Ridder, 2002, [49])

2.5.2. Changing role of the contractor

Increasing responsibilities of the private contractor has changed the role of the construction company in the Netherlands over the last few years. Construction companies nowadays have to act more as a project developer instead of the traditional role of only realizing designs. Being a project developer new expertise has to be gained to stay ahead of competition. Activities in the field of designing, financing and maintaining have to be included in the companies and on project teams. Initiatives to do so could be witnessed over the last couple of years with the founding of BAM PPP, DHV Investments and Arcadis Investments.

Next to changing role of the traditional construction companies, project developers from other fields of expertise see opportunities in the public private partnerships [32]. These traditional project developers have the know-how in the field of marketing and financing of such projects and are attracting design and construct knowledge by forming alliances. In the civil engineering market vertical integration and consolidation increases pace [14]. Offering a solution instead of offering construction works is key-focus of the new playing field of civil engineering [49].

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[4] Public-Private Comparator (PPC) is a rough instrument to compare the additional value of a PPP-structure to traditional tendering in an early phase

[5] Public Sector Comparator (PSC) is a calculation method in which the costs and benefits over the whole lifecycle are analyzed. Based on PSC-outcomes decisions are made on the possibilities of PPP-tendering.

3. THE SCOPE OF THE RESEARCH

3.1 Problem and opportunity definition

The introduction of the DBFMO-contract and the increase of private project developer taking on large construction projects caused a changed playing field on the Dutch construction market. The new playing field causes a new situation:

- New challenges for Royal Haskoning
- Opportunities for Royal Haskoning
- New fields of interest

3.1.1 New challenges for Royal Haskoning

Challenges for Royal Haskoning have been raised in large DBFM-projects over the last few years. Follow from internal presentations and market tendencies the most important changed boundaries can be identified [32] [53] [54]:

- Royal Haskoning is asked to participate in risk and reward of PPP-projects. Co-investing in these projects has become a competitive requirement. Next to the wishes of the SPV, as well the engineering consultancy is part of the due diligence. By participating in risk and reward Royal Haskoning can distinguish itself from other engineering consultants. Secondly by taking part in the risk and reward the credibility of the advice is increased.
- By taking on the role as a central party in a project organization, Royal Haskoning can commercialize its expertise and relationships with other actors. With forming consortia or hiring external expertise otherwise opportunities have arisen to take a more active role in projects.
- Possibilities to exploit profit potential in projects in which Royal Haskoning is hired as engineering consultants. By having much experience in many fields, good investment opportunities can be identified.
- With new contract forms on the market, knowledge and experience in the field of finance is a competitive strength. Creating maximum value for its customers means that Royal Haskoning has to consider the financial consequences as well. In order to give successful options the commercial side and opportunities have to be analyzed more and more.

Summarizing the pre-mentioned challenges, it means that Royal Haskoning is challenged to act more from the perspective of project developer and equity investor (see Figure 12).

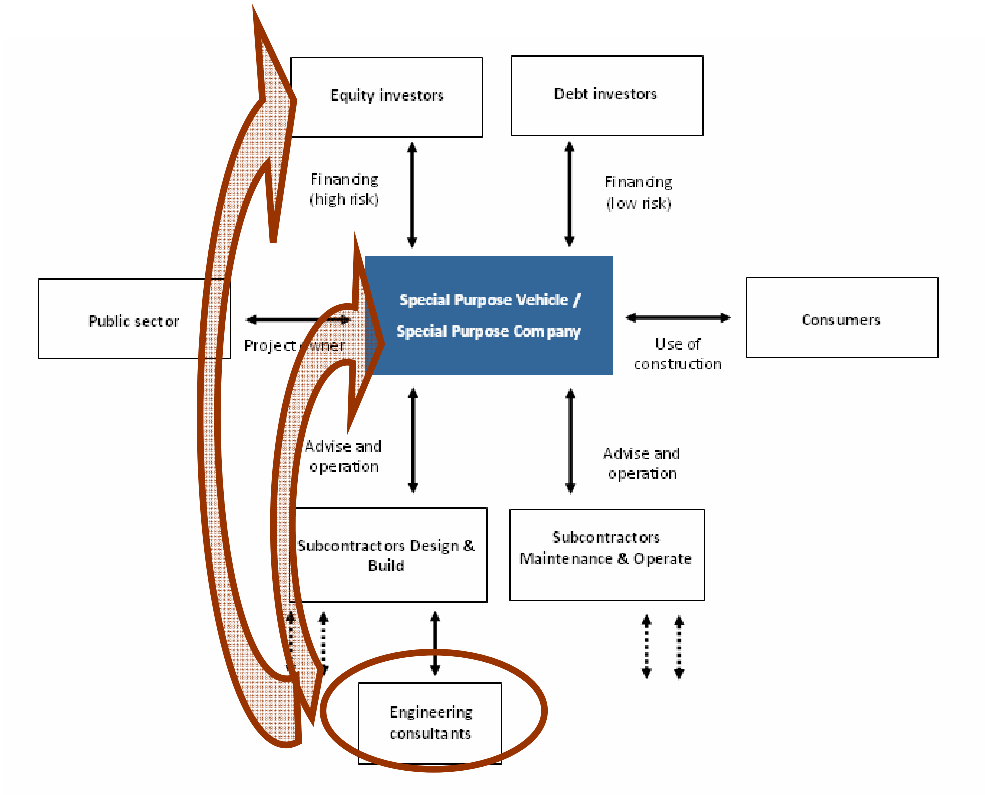


Figure 12 Change of role of engineering consultant to take part in SPV and equity provider

3.1.2. Opportunities for Royal Haskoning

Challenges in a changing playing field offer opportunities for Royal Haskoning. Thinking as a project developer and investor has advantages for both Royal Haskoning itself and its customers. From internal analyses and tendencies in the market, opportunities can be identified [32] [53] [54]:

- The product Royal Haskoning delivers, gains credibility if Royal Haskoning is participating in the risk. Investing corporate equity shows that the board of management backs up the quality of the work of its employees[6].
- By acting as investor profit can be made on attractive investments by commercialization of present expertise and contacts
- Possibilities to proactively push projects on the market. Based on technological insight of projects and know-how of technological innovations, market feasibility can be investigated.
- Thinking from a different perspective as well Increases the challenges for the employees. Royal Haskoning itself benefits from creative and innovative solutions. Secondly employees can also expand their commercial knowledge.

3.1.3. New fields of interest

In civil engineering new non-technical competencies are introduced that are needed in order to create additional value. Traditional engineering advice in larger projects is more and more interconnected with the financial side as described in chapter 2. Since the private financing is relatively new to civil engineering a lot is unknown. Financials and civil engineering companies both

[6] The concept of "putting money where your mouth is" is in the Netherlands already more familiar in strategy consultancy (e.g. Bain&Company) and longer term private equity parties (e.g. HAL investments)

value the project differently. Banks have little insight in the technological aspects of constructions. civil engineering companies on the other hand have little experience with financing projects. The SPV has a central role in translating the design to a financial model and visa versa. Currently technological risks marginally find their way into the financial model.
In the last decade the probabilistic cost estimations was developed further. This method facilitates the cost estimation of technological risks and unforeseen events. In life cycle cost estimations certain features of parts of the construction take into account the expectation over the project life cycle. Combining these two methods results in a spread of the costs and duration expected for the project. Based on this output the financial model has to be constructed. So uncertainties and risks find their way into the cost estimations. However the effect of these uncertainties and risks on the projects course and financing of the project is more difficult to determine.

3.2 Research goal

The goal of the research is to investigate how engineering consultants can take on a more active role in projects as project developer and investor. This is done by:

- Investigating in what way technical risk in civil engineering can be translated optimally into the financial risk. This is the basis for the financing structure. This is done by studying currently used project valuation methods in both civil engineering and corporate/project finance. Next to this the influence of flexibility on the valuation is studied
- Determining critical factors which influence the profitability and successfully investing in projects.

The research is applied in practice to the development of fully automated car parks underneath the canals in Amsterdam by Royal Haskoning.

3.3. Research model & strategy

Based on theories and practices of financing civil engineering projects the relation between technical risk and risk in investments is studied. This is done by a study on four areas:

- Pre study on the roles in project development in civil engineering
- Project valuation in civil engineering and in corporate/project finance
- Valuation of flexibility in civil engineering and in corporate/project finance
- Risk factors in civil engineering and in investment decisions

This literature research results in a conceptual model how risk in civil engineering can be translated into a financing structure. Secondly criteria and possibilities to invest in civil engineering projects are determined. This conceptual model is combined with the views of the stakeholders in civil engineering projects, as shown in figure 9.
With the resulting model and criteria technical risk can be assessed for a business case. With this business case Royal Haskoning gains insight how a engineering consultant can optimally invest in civil engineering projects. This is applied in practice on the development of automatic car parks underneath the canals of Amsterdam. The research model is shown schematically in Figure 13.

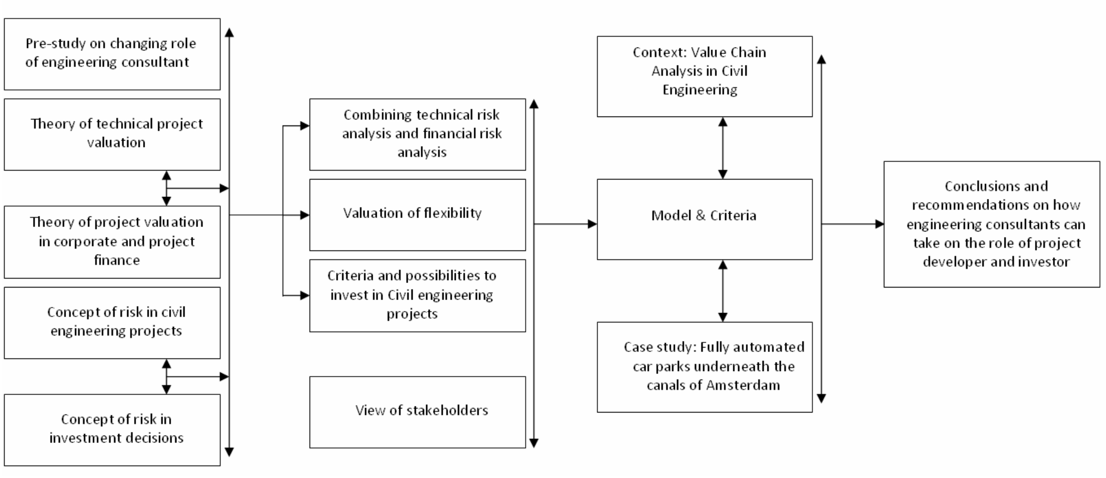


Figure 13 Schematic representation of research model

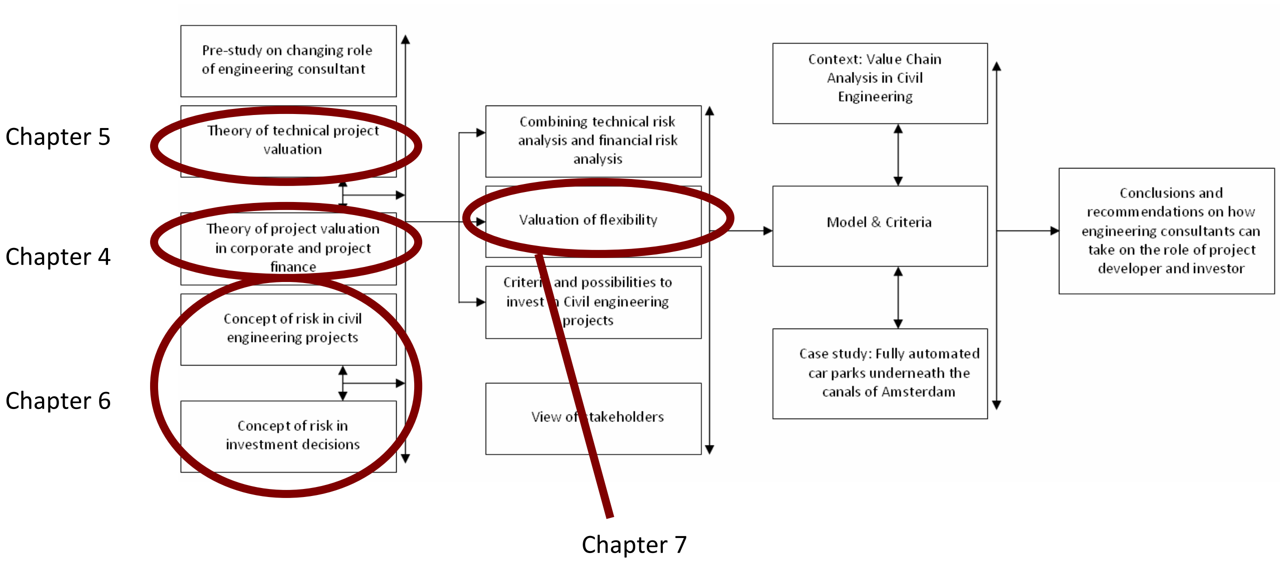
3.4. Research questions

From the goal of the research several main research questions can be filtered:

- Q1. How are projects valued from a technical and financial point of view? How is uncertainty valued?
- Q2. Which risks are perceived from a technical and financial side of a project? Which factors and risks influence the value for both points of views? What is the relation between both risks?
- Q3. What is the role of project flexibility in the valuation? How does it influence the financing structure?
- Q4. What are criteria and possibilities to invest and develop in civil engineering projects?

PART II: PROJECT VALUATION

The decision to invest in a project depends on the expected value the project has. However, the technical and corporate finance approach to project valuation differs from each other. Both approaches are based on the risk a project carries with it. However, the valuation of these risks is incorporated differently. In this part, project valuation from a civil engineering point of view is given. As well project valuation theory in corporate finance is described. Next to this, part II offers approaches to value flexibility and uncertainty over the course of a project.



4. DISCOUNTED CASH FLOW MODEL

"Value is driven by (a project) its ability to earn a return on invested capital greater than its weighted average cost of capital, and second, by its ability to grow"[75]

4.1. Introduction

Project valuation in business and economics theory consists of several models. In this chapter the project valuation methods from the business and economics perspective is described. In project finance the most common used valuation model is the Net Present Value model, which is central in section 4.2. In this model the cash flows are modeled and discounted to present. The two parameters that are included in the model are the free cash flows (section 4.3) and the discount rate (section 4.4). Another method for valuation of a project is by the Capital Asset Pricing Model (CAPM) (section 4.5). According to this model the return of a project is related to the risk of a project. An alternative to the CAPM model is the multifactor model of risk, which is described in section 4.6. According to this model the total risk can be divided into separate parts of risk. The last section (section 4.6) of the chapter covers the determination of the cost of capital. In this section the relation between the CAPM and the financing structure is discussed.

4.2. Net Present Value model

Economic project valuation can be done using the discounted cash flow model (DCF). In order to valuate a project with using DCF, all the cash flows related to the project have to be forecasted and discounted to a reference date. Most commonly used method is the Net Present Value method (NPV). In this theory future cash flows (FCF) are discounted to the present and the initial investments subtracted. For the reference date of present, generally the start of project is used. The net present value (NPV) is determined by:

$$NPV = \sum_{t=0}^{T} \frac{FCF_t}{(1+r_E)^t} - I_0 \qquad (4.1)$$

With:

FCF_t = free cash flow in period t

r_E = External discount rate

T = number of periods

I_0 = initial investment in project.

An investment in a project is attractive if the DCF-model yields a positive value. In the NPV-model this holds for:

$$NPV > 0 \qquad (4.2)$$

As a variation to the NPV, as given in formula 4.1., many ways of valuing a project can be differentiated from the principal of the DCF-model. These methods differ in the definition of the two main variables of the NPV.

- Free Cash Flows per period (measure)
- Intertemporal value of money (discount factor)

In [69] [70] en [75] several other economic valuation methods based on the DCF-model are described. Each method uses a different measure and discount factor. Commonly used discount factor is the Weighted Average Cost of Capital (WACC). The WACC is a percentage of what the capital will cost to reserve per time period of the investment. It can function as a threshold of what return an investment should yield per time period in order to be profitable. The valuation method to be used depends on the features of the project to be valued and the characteristics of the capital structure. In Table 2 an overview of methods is given:

Model	Measure	Discount Factor	Application
(Enterprise) net present value	Free cash flow	Weighted average cost of capital	Valuation of projects with free cash flows and stable capital structure
Economic profit	Economic profit	Weighted average cost of capital	Valuation based on value creation over cost of invested capital
Adjusted present value	Free cash flow	Unlevered cost of capital	Valuation of projects with changing capital structures
Capital cash flow	Capital cash flow	Unlevered cost of equity	Valuation based on return on capital
Equity cash flow	Cash flow to equity	Levered cost of equity	Valuation based on return on equity

Table 2 Valuation methods based on DCF-model [75]

Based on the characteristics and data of the project, which is valuated, a combination of above mentioned methods can be used to value the project. In DBFMO contracts the investment decision of a project is made by a private project developer. The two characteristics of the DCF-method applied in civil engineering projects are discussed in the next paragraphs.

Another commonly used method is the valuation of the Internal Rate of Return (IRR) (Berk & DeMarzo, [69] p 152):. This method is based on which discount factor should be taken in order to reach a positive value for the DCF method. This IRR can then be compared with the achievable WACC. For the NPV-model this results:

$$0 = \sum_{t=0}^{T} \frac{FCF_t}{(1+IRR)} - I_0 \qquad (4.3)$$
$$IRR > Opportunity \cos tofcapital$$

In early phases this methods gives a framework to value an individual project and judge its feasibility. Secondly this method can be very useful to get a feeling for the sensitivity of the NPV to estimation errors in the cost of capital. However for extensive project valuation this methods show limitations. One limitation is the need for an iterative solution. Next to this it is impossible to compare different projects with the IRR. The IRR depends heavily on the project specifications. Thirdly numerical problems can arise in with certain boundary values. This can result in multiple or non-existent IRR's.

Discussion exists about the completeness of the NPV method. Smit (2004, [57) argues that a project should not be valued on itself, since interaction with other projects exist. A formula is given for the expanded NPV in order to value projects with additional criteria on top of the stand-alone value of the project.

Expanded NPV = (standalone value of the project – price) +
(Expected value of synergistic opportunities + flexibility value + strategic value) (4.4)

The valuation of synergistic opportunities arises from the interaction of the project with other parallel projects. These advantages can be caused by improvement through learning or scale advantages. The flexibility of projects can be valued by considering the timing of decisions. If investment decisions can be transferred to a later point in time, the value of the project can be increased. This valuation is discussed in chapter 7. The strategic value depends on the competition in the market. The strategic value is perceived of doing the project self instead of a competitor. Especially in cases where a specific market share or knowledge advantage is desired in a specific area, the strategic value increases.

4.3. Free Cash Flows

As described in paragraph 1.2., several stakeholders play a role in a DBFMO contract. By the interaction between the stakeholders cash flows are generated. The cash flows in PPP projects is shown in Figure 14.
Financing a project in civil engineering is largely determined by the characteristics of the cash flows between:

- Public sector and SPV. This cash flow towards the SPV can be split up in a payment for availability and payment per use. This is shown in panel b of Figure 8. The cash flow towards the public sector are the fines and non-conformance costs. Per project these are determined in the contract between the project owner and project company.
- Investors and SPV. The cash flow that is generated during the operation phase of the project is used firstly to repay the investors. The debt investors are more senior than the equity investor. Therefore it is assumed that net generated cash flow is first used to repay interest. After the debt is resolved the return on equity invested is paid. In the figure the cash flows due to recapitalization are not shown. Recapitalization takes place when the overall project risk is expected to change. This can be either planned in advance or renegotiated with the investing parties [39]. During DBFMO-projects this can lead to additional cash flows between equity investors and debt investors.

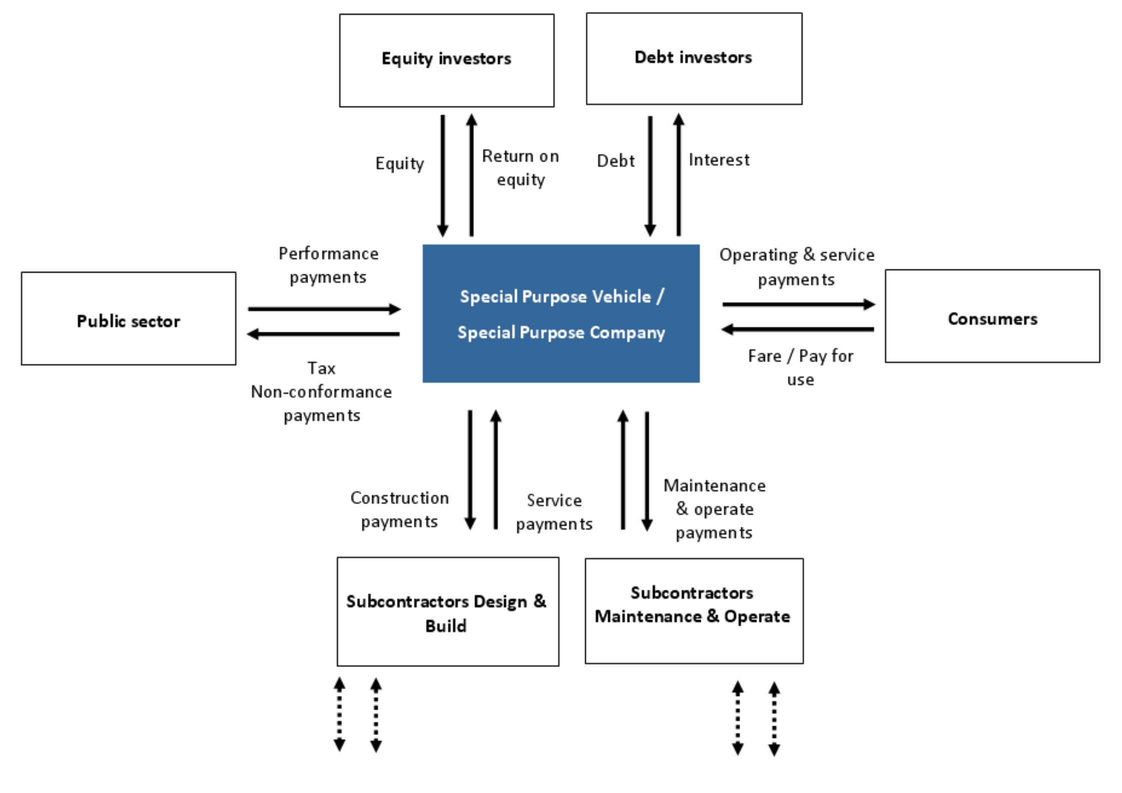


Figure 14 Overview of cash flows in a project

The relation between the cash flows and the model representation is discussed later on.

4.4. Discount Rate

As discussed, the discount factor to be used varies per valuation method and depends on project characteristics. Since the discount factor determines the value of money in a next time period, it is also referred to as the intertemporal value of money. In the NPV-method generally the Weighted Average Cost of Capital (WACC) as discount factor is used.

The WACC incorporates the risk of the project and the finance structure used based on this risk. It reflects the costs of money per unit of time. The WACC of levered equity is equal to the cost of capital of unlevered equity plus a premium that is proportional to the market value debt equity ratio (Modigliani & Miller, 1958, [44]). The risk premium required on equity or on debt depends on the risk involved in the investment. To value this risk the Capital Asset Pricing Model (CAPM) (Sharpe, 1964, [56]) can be used. This theory gives a framework for assessing the interest rate related to the risk.

Although WACC is used generally in enterprise DCF methods, characteristics of projects can force other discounts factors to be used. When the capital structure of a project changes, formula 4.1 have to be adjusted for this in each period. Secondly if different projects, with each a different financing structure, have to be compared with each other, a constant discount factor can be chosen. The characteristics of the capital structure are then included in separate financing costs. However this adjustment leads to a less insightful assessment of market feasibility. This is the case because the NPV can give a positive value although the profits are not exceeding the cost of capital.

In civil engineering practice therefore a sort of the adjusted present value method can be used. The discounted factor is a interest rate given by the project owner. This discount rate is a relative return level to which the market feasibility should be assessed. The costs of the capital structure are included as separate costs. This method is described in [19]. For the discount rate a constant rate of 4% is determined.

Formula 4.1 can be rewritten with the free cash flow characteristics and the discount factor characteristics for civil engineering projects. The cash flows as shown in Figure 14 can be split up in flows due to costs and to income. As discussed an externally determined rate is used as the discount factor. The cost of capital is taken into the model with separate finance costs. The model can be described as:

$$NPV = -\sum_{t=0}^{T} \frac{FCF_{costs}}{(1+r_f)} + \sum_{t=0}^{T} \frac{FCF_{income}}{(1+r_f)} - \sum_{t=0}^{T} \frac{FinanceCosts}{(1+r_f)} \qquad (4.5)$$

In which

$$FinanceCosts = f(FCF_{costs}, FCF_{income}, r_{WACC}) \qquad (4.6)$$

FCF_{costs} = Free cash flows due to costs of the project
FCF_{income} = Free cash flows generated by the project
R_f = Externally determined discount rate for all tendering parties equal
r_{WACC} = interest rate based on the weighted cost of capital

4.5. Capital Asset Pricing Model

The required return on a risky investment in finance is commonly assessed using the Capital Asset Pricing Model (CAPM) (Sharpe, 1964, [56]). First developed for valuing stocks, later on the theory was applied to value equity, projects and physical investments as well. The valuation depends on 3 variables:

- Risk free interest rate (r_f), commonly based on state bonds with the same maturity as the project
- Expected overall market return ($E[r_m]$). This is the overall performance of a fully diversified market portfolio. The expected overall market return depends on the market risk or non-diversifiable risk.
- Risk of the individual investment. This is generally denoted as the covariance between the expected return of a project and the expected return of the market divided by the market risk (βp).

The CAPM states that the required return of project consists of the risk-free interest rate and a premium, which compensates for the risk of a project. Therefore a riskier investment requires a higher expected return. In Figure 15 an overview is given of the risk involved with an investment and the return for global listed traditional and alternative assets [54]. From this figure follows that financing infrastructure and public real estate can reduce the risk on the investment largely, with a small decrease of expected return.

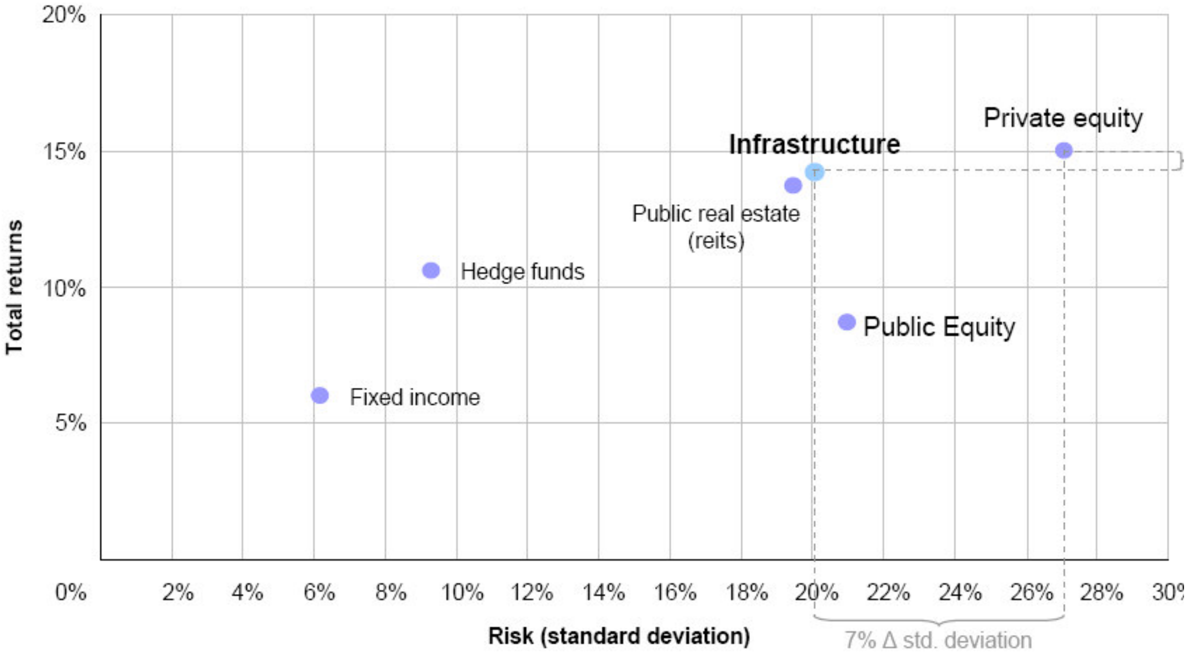


Figure 15 Returns on global listed traditional and alternative assets (march 2007, ten year) [54]

The CAPM is quantitatively given by:

$$E[r_p] = r_f + \beta_p(E[r_{market}] - r_f) \quad (4.4)$$

With:

E[rp] = expected return of project

Rf = risk-free interest rate

E[rmarket] = expected return of the total market

$E[r_{market}] - r_f$ = market risk premium is the expected return of the overall market over the risk free interest rate

βp = project beta expressing the project risk in comparison to market risk

$$\beta_p = \frac{Cov(R_p, R_{market})}{Var(R_{market})} = \frac{\sigma^2_{p,market}}{\sigma^2_{market}} \quad (4.5)$$

If a project is riskier than the overall market this results in a βp >1. If the project carries less risk than the market, than βp < 1.

Important in determining the projects required return is estimating the project's β. For daily traded assets the beta is determined analyzing the fluctuation of the assets price relative to the market fluctuations using formula 4.5. However for non-traded assets and projects different methods have to be used. From [34] [69] [70] en [75] follows that for non-traded assets betas are generally estimated:

- using historical project data
- using beta's from comparable projects or industries
- using expert opinions

In practice especially the expert opinions based on the project perceptions and experience of the bankers determine the beta. Historical project data is scarcely registered and difficult to compare due to budget overruns and project scope changes (Flyvbjerg, 2003, [74]). Taking beta's of comparable projects is hard because of the dependencies on local circumstances. On first sight alike projects can be to a large scale different due to local variations. Beta's of industries can be taken as estimations. However these beta's can result in large errors if applied to individual projects.

4.6. Multifactor model of risk

An alternative to the CAPM is the Arbitrage Pricing Theory (APT) (Ross, 1976,[52]). According to this theory the total risk of an asset can be constituted from a series of risk factors contributing each to the total. For each risk a separate beta has to be determined. In the case no arbitrage is possible with each of the individual risk, the expected return is approximately linearly dependant on each of the factors. This theory offers the opportunity to cut a projects beta into separate beta's in the case the arbitrage assumption holds. If in this model the CAPM notation of the risk premium is applied, it results in:

$$E[r_p] = r_f + \beta_p^{p1}(E[r_{p1}] - r_f) + \beta_p^{p2}(E[r_{p2}] - r_f) + .. + \beta_p^{pn}(E[r_{pn}] - r_f)$$

$$E[r_p] = r_f + \sum_{n=1}^{N} \beta_p^{pn}(E[r_{pn}] - r_f)$$

4.7. Cost of capital

With the CAPM an expected rate of return can be determined for all investments, based on the risk of the investment. With r_E and r_D assessed by the CAPM and resulting from formula 4.4, the cost following from the capital structure, r_{WACC}, can be determined (Berk & DeMarzo, [69] p 465):

$$r_E = r_f + \beta_E[E(r_m) - r_f]$$

$$r_D = r_f + \beta_D[E(r_m) - r_f]$$

$$r_{WACC} = \frac{E}{E+D} r_e + (1 - \tau_c) \frac{D}{E+D} r_D$$

With

E = Amount of equity invested in the project

D = Amount of debt invested in the project

r_E = Cost of equity

r_D = Cost of debt

τ_C = Tax-rate on debt

This formula gives a weighted average of all the financing components. In civil engineering practice generally mezzanine finance is part of the capital structure. The principle of formula 4.8 is then extended with a component for the mezzanine finance. In Figure 16 a graphical overview of the capital structure with mezzanine finance is given.

In the calculation of r_{WACC} the tax rate on debt is included. With tax-deductible interest on debt, the borrowing interest rate is reduced with the tax rate. Since part of the project is debt financed, this can yield a benefit through cheaper financing each year. Including the benefit gained from the tax on debt is referred to as the Interest Tax Shield (ITS).

From formula 4.8 and Figure 16 can be concluded that if the capital structure changes, the risk of the project changes. The risk due to financial leverage can be understood that in the case with lower income the revenue lost is higher with higher leveraged projects. However, vice versa holds as well. If the project risk changes, the capital structure should change as well. This follows as well from the assumption of perfect capital markets stating that the risk and WACC are dependant (Modigliani & Miller, 1958, [44]).

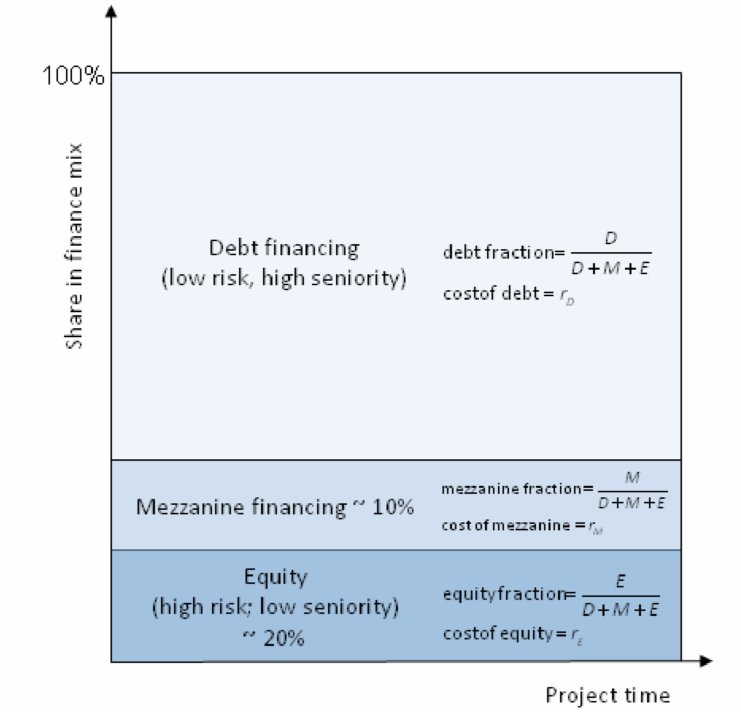


Figure 16 Graphical representation of parameters contributing tooWACC

In this chapter…

Project valuation in business and economic theory is done by the discounted cash flow method. If the Net Present Value is positive a project generates more money than it costs. Although this method is widely applied, discussion exists on whether the method should be extended by taking the value of flexibility and strategic choices into account. The two most important parameters of this method are the free cash flows and the discount rate. The free cash flows can be modeled by assessing the cash flows during the project's course between the stakeholders of a project. For the valuation of civil engineering projects the WACC can be taken as discount factor. The cost of capital (WACC) is the weighted average costs of the components of the financing mix. The cost of a financing component is the return which the components should at least yield. The WACC is related to the risk of a project. In the CAPM model there is a relation stated between the risk in a project and the required return. The beta parameter of the CAPM is a measure for the risk of a project. According to the multifactor model of risk the total risk of a project can be divided into separate portions of risks each having their separate beta. The required return retrieved from the CAPM can be compared to the cost of capital (WACC).From previous studies the required return for various sorts of projects can be retrieved.

5. PROJECT COST & REVENUE ESTIMATION

5.1 Introduction

In the previous chapter the valuation theory from the business and economics point of view was discussed. This chapter covers the project valuation in civil engineering practice. The frameworks for cost estimations are described in section 5.2. With the introduction of the innovative contracts the cost estimations are extended taking the entire life cycle into account. The NEN guidelines which describe the components of the life cycle cost analysis are presented in section 5.3. In section 5.4 is described how uncertainty can be taken into account in the cost estimations. The two approaches that include uncertainty are central in section 5.4. In section 5.5 a closer look is taken at the probabilistic estimation method, one of the two approaches described in the previous section.

5.2. Standard Systems for estimating costs in civil engineering sector

Based on former NEN 2631 legislation and Project Estimation Infrastructure (Dutch: PRI), the national knowledge center for traffic, transport and infrastructure CROW developed a framework for uniform cost estimation (CROW, 2002, [71]). The standard system for cost estimations in civil engineering is shown in Figure 17 (Dutch only).

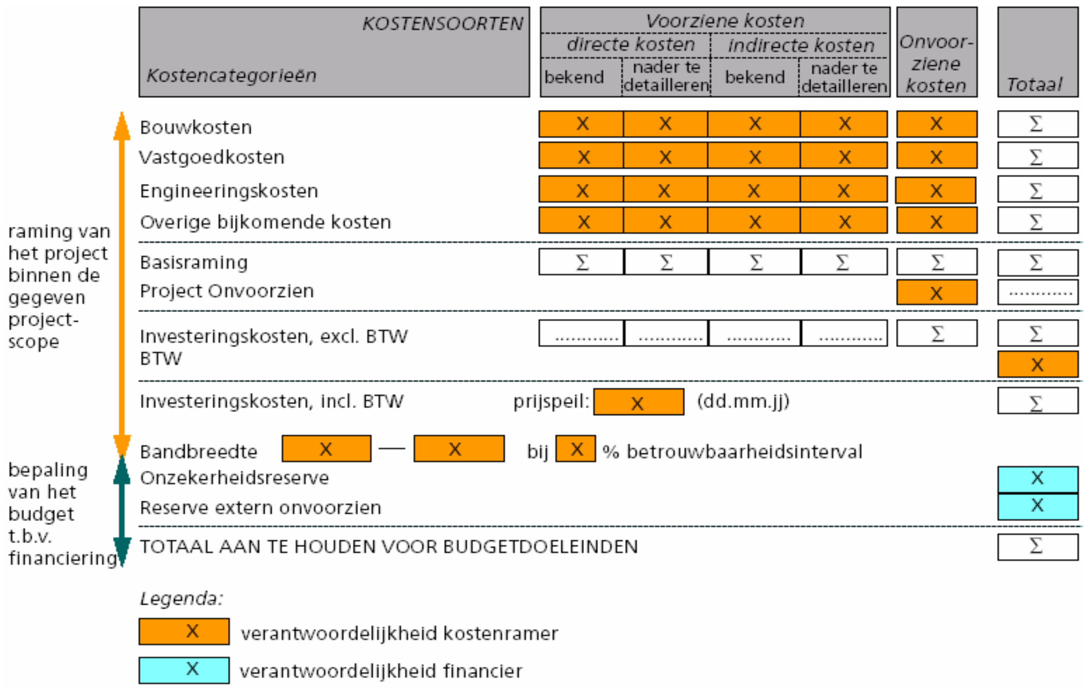


Figure 17 Framework for uniform cost estimations

In this framework horizontally the cost sorts are shown. The foreseen costs can be split up in known costs and unknown costs. The uncertainty of the unknown costs is taken into account with normal spreads on each of the cost categories. The unforeseen costs are determined by events during the project which are not anticipated on. For the determination of the unknown and unforeseen CROW proposes standard methods. The relation of the known, unknown and unforeseen costs in the total bid sum is shown in Figure 18.

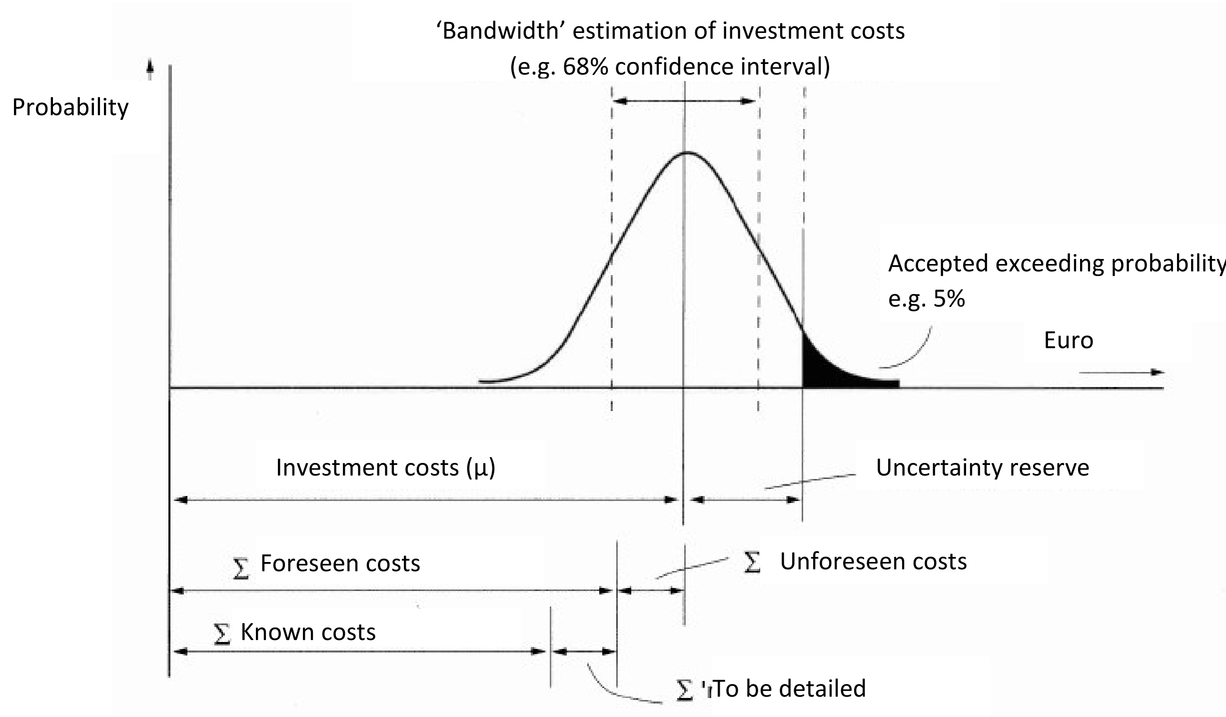


Figure 18 Contribution of uncertainties to project cost estimation

The management choice how far the bid sum exceeds the expected costs depends on various parameters:

- the uncertainty of the project (the width of the density function)
- the portfolio of the company
- the opportunity of additional work
- strategic considerations on employment or knowledge grounds

According to [71] a value of 0,5 – 2 times the standard deviation is chosen in practice for projects.

5.3. Life Cycle Cost Analysis

With the introduction of DBFMO contracts in construction a shift of focus was made from technical life cycle analysis towards economical life cycle analysis, as described in [76] and [61]. By giving the responsibility of the initial investment and during operation to one party, economic optimization over the life cycle was made possible. Because of the lone period of operation, the costs of operation and maintenance are generally significant. When focusing on the technical life cycle components are replaced or assessed on if they can still fulfill the technical requirements. With the focus on life cycle costs components are replaced when an economic cheaper alternative is available.

In the Life Cycle Cost Analysis (LCC-Analysis) the costs and benefits over the entire project life cycle are considered. The four components of the analysis are described in Figure 19.

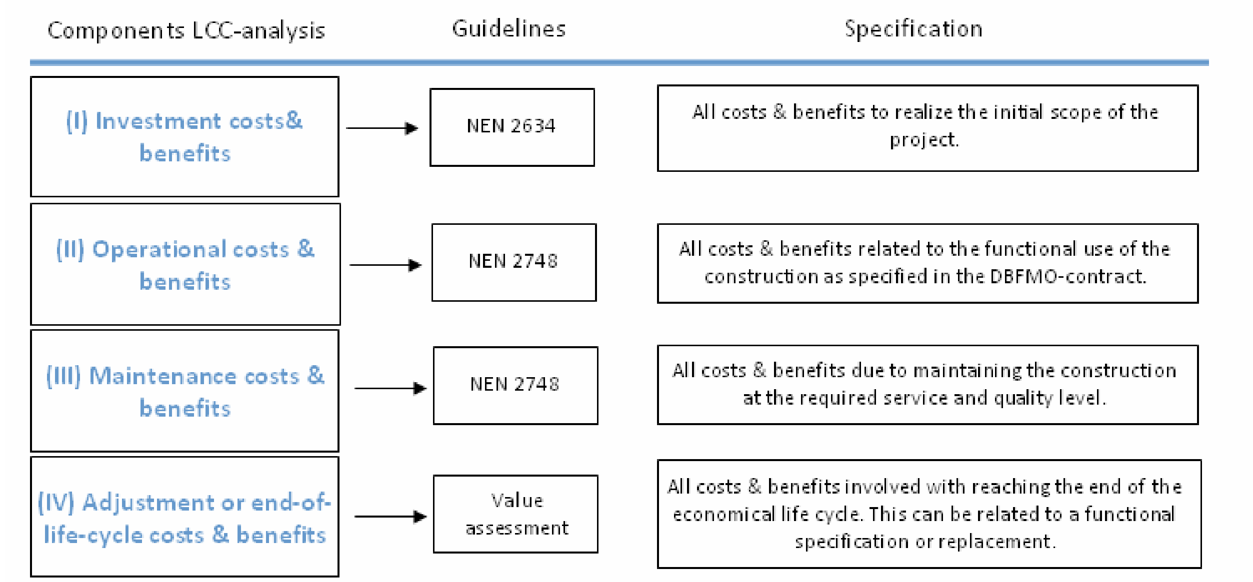


Figure 19 Components of the Life Cycle Costs analysis

5.4. Uncertainty in cost estimations in civil engineering

In a budget and project planning three types of uncertainties can be included (Vrijling, 2008, [78] & CROW, 2002, [71].

- Normal uncertainties or knowledge uncertainty
  Normal uncertainties deal with posts that are surely happening, however of which the expected value is uncertain. The bandwidth on the expected value occurs due to lack knowledge of the cost parameters in the future. These uncertainties occur in quantity, price and duration.

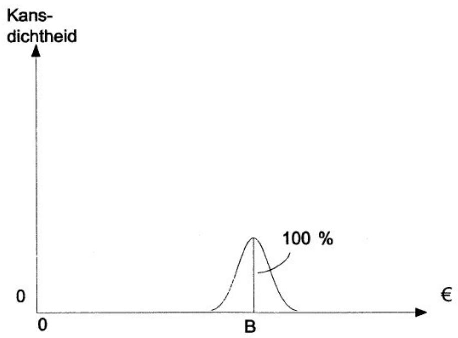


Figure 20. Probability density function of the consequences of a normal uncertainty

- Special events or future uncertainty
  Special events are not likely to occur, however with relatively great consequences. The consequences of a special event can have a deterministic value or a spread. In the cost estimations reservations can be made for these special events. Special events are unforeseen due to future uncertainty. The unforeseen costs are the sum of the reservations estimated with active project risk management. Research shows that unforeseen events in civil engineering projects do happen and have a significant contribution to the budget or planning (Boschloo, 2001, [6])

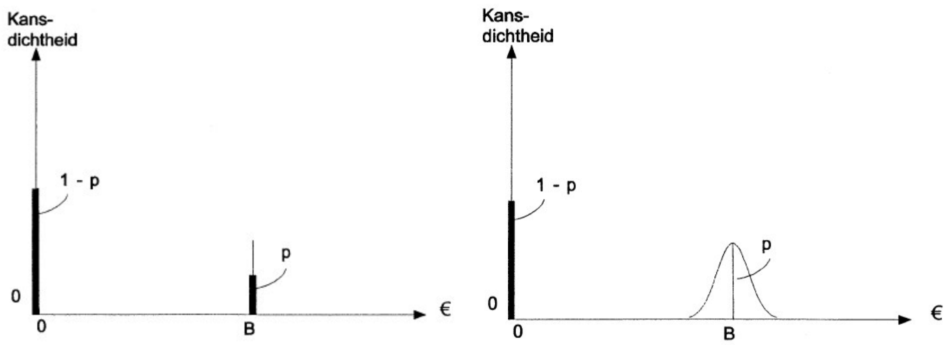


Figure 21. Probability density function of the consequences of a special event

- Plan uncertainties or decision uncertainty
  Plan uncertainty in cost estimations arise if multiple alternatives for one cost category have to be included. In early phases multiple costs estimations are generally made for each variant. However when one integrated estimation is needed, a probability density with two likely outcomes can describe the plan uncertainty. When a decision on this alternative is made, the distribution forms into a distribution of a normal uncertainty.

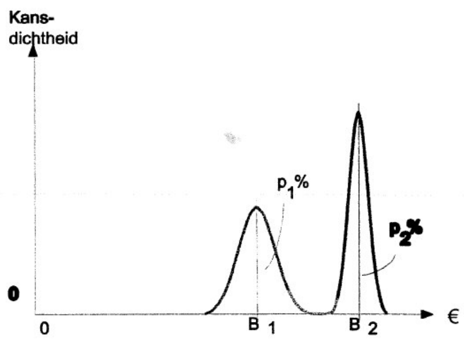


Figure 22 Probability density function of the consequences of plan uncertainty. Two peaks are showing two alternatives

Over the project phases the sum of all uncertainties is expected to decrease. If the scope of the project over the phases stays constant and the budget includes all uncertainties, the bandwidth of the cost estimation decreases. The extreme value of the total cost distribution stays within the boundaries set by the initial estimation.
However, changes in project scope occur frequently in civil engineering (Vastert, 2001, [60]). Especially changed legislation and whishes by the public sector are examples of these. This results in a shift of the budget to a higher or lower value outside the extreme boundaries set by the initial estimation. Uncertainties due to scope changes have to be analyzed for financing and compensation reasons.

5.5. Cost estimation approaches

To include uncertainties in the budget or time planning two approaches are used in civil engineering practice (Vrijling, 2008, [78] & CROW, 2002, [71]).

Deterministic approach

In this approach uncertain and unforeseen costs are taken into account by a margin added on the initial cost estimation of the direct and indirect costs. The margin is generally a percentage of the subtotal foreseen costs. The bandwidth is based both on experience in comparable projects and on the expected uncertainty of the project. Each phase calculates the total cost applying a different margin. In the pure deterministic method the margin is a fixed percentage of foreseen costs. In the black box method the margin is a bandwidth of a probability distribution of the total costs. This method is generally used in early phases of the project, when a risk assessment has not yet been made.

Probabilistic approach

In the probabilistic approach the uncertainties as described in previous paragraph are taken into account per cost category. The distributions of the normal and plan uncertainties are included in the foreseen costs. The distributions of the special events are included in the unforeseen costs. Main advantage of the probabilistic approach is the transparency of the contribution of each individual uncertainty to the total budget. Foreseen and unforeseen costs are assessed independently. The spread in the uncertainty decreases over the course of the project. This results in a narrower distribution of the cost estimation.

In what way risks are included in the cost estimation depends on the method used. For the probabilistic approach three methods are applied.

5.6. Probabilistic estimation methods

Simple Level II method

The most straightforward method is to include uncertainty by “risk= chance * consequence” in combination with a standard deviation. Doing so for each factor a standard distribution is assumed. By adding all these contributions and applying the Central Limit theorem, a normal distribution of the costs is retrieved. This method, however, reduces the insight of the form of the probability density function of the total cost estimation. Advantage is the ease of application and simple calculation with spreadsheet programs. Next to this dependencies can be taken into account.

Level II calculation

In a more refined level II calculation the probability distributions of each contributing parameter are taken into account. By identifying different distributions and their relative importance, a more insightful analysis of the costs is made. The risk contributing to the overall spread can be identified easily. However in this method the parameters are assumed independent. Secondly discrete distribution, such as some special events can not be included in the calculation.

This calculation method can be described as follows:

$$Costs = C(X_1, X_2, .., X_1)$$

With

$$\mu_K = C(\mu_1, \mu_2, .., \mu_N)$$

$$\sigma K = \sqrt{\sum_{i=1}^{n} \left(\frac{\partial K}{\partial X_i} * \sigma_{Xi} \right)^2}$$

Level III calculation – Monte Carlo simulation

In a Monte Carlo simulation numerical simulations are done, based on the probability density functions which are specified for each parameter. Each parameter gets a value that is drawn from each specified distribution. The total costs of each simulation can be calculated based on these randomly generated parameters, using:

$$Costs = C(X_1, X_2, .., X_1)$$

If this process is repeated many times, the outcomes can be plotted in a histogram. This histograms reflects the probability density function of the total cost.

The probability distribution functions of the underlying parameters of the cost estimations can be determined in two ways:

- Statistical estimation is done by analyzing historical data or analytical studies. These studies focus on finding the distribution function that fits best the data.
- Bayesian estimation determines the probability density function based on opinions of experts. Commonly a triangular distribution function is used. The expert estimates the most likely value and the maximum and minimum value of the triangle. Opinions of multiple experts can be combined by calculating the cumulative distribution function.

In this chapter…
The traditional project valuation of technical projects is performed using a cost estimation. Because of the changing contracts the entire life cycle costs are assessed more often. Uncertainty in the input parameters can be taken into account by a probabilistic cost estimation. Technical uncertainty results in risk reservation and a spread in the investment costs. There are two cost estimation methods which are commonly used: the deterministic cost estimation and the probabilistic cost estimation. For the latter three methods are described. One of the methods is the Monte Carlo Simulation. In the Monte Carlo simulation al input parameters are modeled to have a probability distribution from which values are generated in each iteration of the simulation. Using these generated values one simulated value of the project's results can be calculated

6. RISK ANALYSIS

6.1. Introduction

In previous chapters project valuation methods were discussed in the project finance and civil engineering practice. In the valuation methods risk assessment is an important part. In the CAPM the risk related to an investment is part of the mode. In section 4.7 the link was made to risk in project finance. How risk analysis is included in a DBFMO contract is briefly addressed in section 6.2. This section points out how risk is included in the valuation methods. In section 6.3 the risk classification from the Basel-II accord are described. Using this classification the risks and the qualitative relation between can be described. In section 6.4 some considerations are given on financing risky (DBFMO) projects.

6.2. Risk analysis in DBFMO

Risk Analysis focuses on the uncertainties that are involved with a project. In order to come to a profitable execution of a project within the set time risk analysis is required to anticipate on uncertain and unforeseen events. In practice the risk analysis of a financial institution differs in risk sources than that the technical risk assessment.

$$NPV = -\sum_{t=0}^{T} \frac{FCF_{costs}}{(1+r_f)^t} + \sum_{t=0}^{T} \frac{FCF_{income}}{(1+r_f)^t} - \sum_{t=0}^{T} \frac{FinanceCosts}{(1+r_f)^t} \qquad (5.1)$$

And

$$r_p = r_f + \beta_D[E(r_m) - r_f]$$
$$r_{WACC} = \frac{E}{E+D} r_e + (1-\tau_c)\frac{D}{E+D} r_D \qquad (5.2)$$

If the NPV-formula 5.1 is considered, the focus of the risk analysis from a technical point of view focuses on the uncertainty of the free cash flows from income and costs. The risk analysis of a financial institution focuses generally on the risks involved with the financial parameters, risk of insolvency and market risk. These risks together form the investment risk which is the risk of a too low rate of return.

The beta of the CAPM (see section 4,5) incorporates the risk of a project and is the basis for the required rate of return (formula 5.2a). The WACC gives the average required rate of return, incorporating all the risk assessment of the various risk analysts formula (5.2b).

Risk analysis in civil engineering practice is done using probabilistic cost estimations with normal uncertainties on the parameters. Next to this unforeseen events can be inventoried applying risk management. For this the Risman method is commonly applied in Dutch civil engineering practice.

6.3. Financial Risk Management

In the previous section the different forms of risk in a DBFMO project were described. To get an overview of the different risk categories and the relation between them a classification needs to be made. In this section the risk categorization of the Basel II accord are used.
In 2004 The Basel II accord was published giving an international standard for baking regulators how financial institutions can protect them against the financial and operational risks [1]. The Basel II accords were issued by the Basel Committee on Banking Supervision. The accord is believed to be a protection against default of the financial system and economic stability.
The accord mentions the three major components of risk that financial institutions face:

- Credit risk
- Operational risk
- Market risk

Credit risk

Credit risk is the risk that a debtor is not able to pay back its loan, interest or other credit related payments. In the situation of banks facing credit risk towards businesses, derivatives can be used to protect financial institution against this risk. A credit derivative is a financial product which carries a part of the risk. If this derivative is sold to another financial institution, this third party receives periodic payment, for taking on a part of the risk. If the default occurs the party buying the derivative buys over the debt. Examples of derivatives are:

- Credit default SWAPs
- Collateralized Debt Obligations

Operational risk

The operational part incorporates all risks resulting from characteristics of the organization executing the project. The Basel II accords identify:

- Fraud, internal and external
- Employment Practices
- Business Practice
- Damage to Physical Assets
- Business Disruption & Systems Failures
- Internal Management

This category is the hardest to asses the level of risk. Financial institutions asses this risk generally on intuition and experience. However some standard for risk assessments of operational risk do exist (Indicators and scorecards based methods).

Market risk

The market risk part covers all the risks involved in investing in a risky market. The main groups of market risks are:

- Equity risk; risk that the value of an asset or project changes
- Interest rate risk; risk that the interest rates change
- Currency risk; risk that foreing exchange rates change
- Commodity risk; risk that commodity prices change

Based on this categorization the relation between the risk groups can be made. In figure 23 these relations are depicted. The risk for an investor is the investment risk. In project finance credit risk is not common. The investment risk thus consists of the operational risk and the market risk. The operational risk is divided into technical risk and financial risk. Technical risk covers the risk from construction. Financial risk contains the risk in the financial parameters and the financing risk. Financing risk itself can be divided into risk of insolvency of the financing need and the risk of insolvency of the debt service.

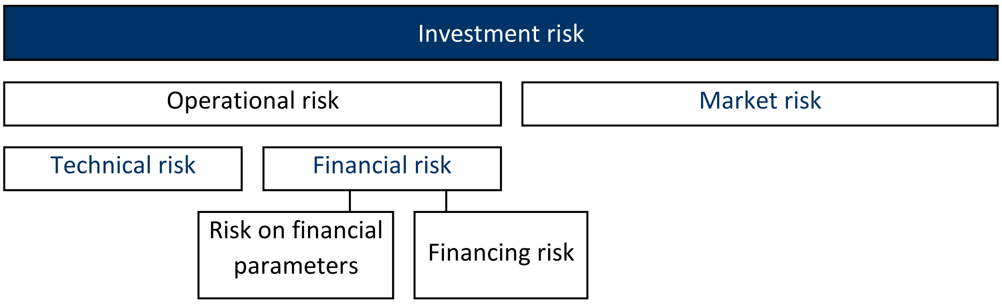


Figure 23 Relation between risks

Exposure to risk

The exposure to market risk by financial institutions is measured using the Value at Risk (VaR). The VaR is the maximum cumulated loss that can not be exceeded with a certain reliability interval within a certain period. The VaR is the concept that a project is chosen that the probability of a certain loss is below a predetermined value. VaR can be applied for a project or portfolio approach. In the last case correlation between projects should be addressed.

$$VaR = \inf \{ l \in \Re : P(L < l \leq 1 - \alpha) \}$$

$$VaR = \mu(L) - n \cdot \sigma(L)$$

$$n = \Phi^{-1}(1 - \alpha)$$

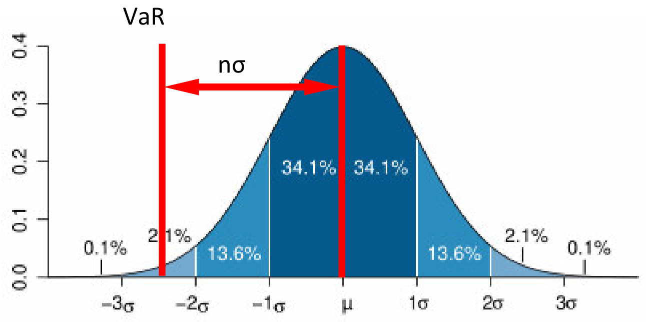


Figure 24 Grapical representation of the VaR in the expected return distribution

The VaR has some basic assumption for its validity. In the VaR the collection of risky assets and other portfolio components should remain the same over the period it references to. This can only hold for shorter time frames. Therefore the VaR should be recalculated periodically. As well representing all the risk in financial terms in one figure, requires an assessment of the correlation of risks. However in many cases this is difficult requirement to hold.

6.4. Financing DBFMO projects

Financing a risky project, such as a DBFMO project, relates the risk of the project into financial parameters and vice versa. If the risk of a project is perceived high, a larger portion of equity is required or a higher interest rate is required. Some considerations of project finance are important:

- If a financing mix consists of debt and equity, first the equity is drawn and then the debt is drawn. This way the equity is totally committed in the project.

- To reduce the risk of insolvency during the financing period, a larger amount of money needs to be committed. However, a larger amount of debt means higher financing fees and a lower leverage factor.
- Working capital need to be reserved in order to pay the running accounts. With this working capital the creditors can be paid and the debtors can be financed. The size of the working capital is determined by the largest difference between the expenditures to be paid creditors and the sum of the costs of the debtors. For the creditors a repayment period of 30 days is generally assumed and for the debtors a repayment period of 60 days is assumed.
- The interest rates required by the debt financer are combined by a base interest rate and SWAP rates. A SWAP rate is a percentage on top of the base interest rate which is related to the risks in that phase of the project. The base interest rate is generally the interest rate of a risk free investment with the same duration.
- The financing costs consist of the Interest During Construction (IDC), commitment fee and a one time financing fee. The commitment fee is a fee for the money that is committed to the project by the bank but not yet drawn. The financing fee is an administrational fee. The financing costs have to be paid by the SPV when the first cash flows in the exploitation phase are generated by the project.
- The repayment of the debt has some parameters which can be varied:
  - Duration of the debt
  - Start of the repayment of the debt after the start of the exploitation phase (grace period)
  - Time between the end of the project end the last debt service. The debt service is the sum of the interest payment and debt repayment per period.
  - Repayment schedule. In some cases it can be optimal to use non linear repayment schedules.

Financing a risky project in the civil engineering playing field has some specific features.

- Financing by the European Central Bank
- Controlling project finance by ratios
- Monitoring by financial institutions

Financing by the European Central Bank (DBFM-handboek, 2005, [39])

Because of the social aspects of investments in infrastructure and public real estate, the public sector is closely involved in the projects. Fore specific projects a part of the project can be financed by the European Central Bank (ECB). The ECB offers a low interest rate. This interest rate is generally lower than the Euribor interest rate, which is the average interest rate for loans between banks.

Controlling project finance by ratios (DBFM-handboek, 2005, [39])

Project finance and the credit risk is generally treated in the financial model. The controlling of the credit risk is done by simulating financial ratios. In general this is done by keeping these ratios above a limit and monitoring them during the project's execution. These ratios are:

- Annual Debt Service Cover ratio (ADSCR) is the ratio to determine whether the cash flows generated by the project can cover the interest and loan-payments
- Loan Life Cover ratio (LLCR) is the ratio to determine is the project cash flows can cover the debt service for the duration of the loan
- Project life cover ratio (PLCR) is the ratio to determine is the project cash flows can cover the debt service for the duration of the project

Monitoring (DBFM sturing door prikkels, 2003, [40])

By privatizing the financing of projects, the financial institution is considered to have a role as guards of the profitability and execution within the pre determined duration. Instead of controlling by the public sector, now the market has to steer projects.

In this chapter…

In this chapter the different risks and the qualitative relation between them are discussed. In civil engineering projects the investment risk consists of operational and market risk. The operational risk can be divided into financial risk and technical risk. The technical risk covers all the risk during the construction phase. The financial risk includes the risk of the financial parameters and the financing risk. The financing risk focuses on the risk of insolvency of the financing reservation and the risk of insolvency of the debt service. In civil engineering project the most important market risks are changes in the interest rates and changes in inflation.

The risk of insolvency of the debt service is assessed by calculating three ratios. These ratios are then compared to threshold values

Debt Service Cover Ratio
Loan Life Cover Ratio
Project Life Cover Ratio

7. FLEXIBILITY VALUE OF PROJECTS: REAL OPTIONS

"The net present value rule is not sufficient. To make intelligent investment choices, managers need to consider the value of keeping their options open [46]"

"In an increasingly uncertain world, real options have broad application as a management tool. They will change the way you value opportunities. They will change the way you think – both reactively and proactively. [33]"

7.1 Introduction

Civil Engineering projects are characterized by long project durations and a large influence of boundary conditions on the project's outcome. In this uncertain environment, flexible design and anticipation on changing boundary conditions is needed. To include this in the valuation traditional discounted cash flow models should be extended with the valuation of flexibility. In this chapter the valuation of real options during a project's course is described.. In section 7.2 the limitations of the traditional valuation methods are described. In the next section (section 7.3) the theory behind real option thinking is discussed. In real option theory 3 methods are described: The Black-Scholes model for the valuation of financial options (section 7.4), Decision Tree Analysis (section 7.5) and Binomial or Multinomial Tree Analysis (section 7.6). This chapter is concluded with a discussion on the applicability of option pricing in real markets (section 7.7) and the advantages of real option analysis (section 7.8).

7.2. Limitations of DCF models

The traditional discounted cash flow model values a project as the sum off all the future cash flows. In this light a project is attractive to invest in if the Net Present Value is positive (see 3.4. The investment decision). Risk and uncertainties are dealt with in this model by assuming that cash flows do not have deterministic values, rather having multiple values or a statistical distribution function. Smit (2004, [57]) argued that next to uncertainty flexibility and strategic importance should as well be incorporated in the project valuation.

With the changing character of civil engineering projects in the Netherlands, both uncertainty and flexibility in project execution increase. New DBFMO-contracts and longer project life times mean more responsibility for the project company and therefore more uncertainty and risk. However increased uncertainty and risk implicitly also means increased opportunities, since not everything has been determined. Opportunities can be created by leaving options open how to deal with new information, the timing of decision and actions of competitors or stakeholders. In the probabilistic cost estimations and other Discounted Cash Flow models these aspects are not included in the project

valuation. By including the value of flexibility in current DCF methods, attention is directed on taking advantage of opportunities from a changing playing field.
The increase in project scale in civil engineering also increases the project duration. The longer duration incorporates large uncertainties and significant changes in boundary conditions, which can not be taken into account by designers. New technologies may arise which make older ones or technology dependant infrastructure redundant. New economic or political circumstances may have a positive or negative influence on the projects return. Uncertainty in these boundary conditions may cause situations which differ from the forecasts (Flyvjberg, 2003, [74]). These changes can cause different outcomes of the DCF method. Recognition of a changing environment is not included in the current DCF methods. In this chapter some methods are described how valuation methods can take flexibility into account.

7.3. Real Options

The Real Option theory is based on financial options. An option on the financial market is the right to buy or sell a stock at a certain price before some expiry date. The holder is not obligated to execute his right before or on the date the option expires. In general there are two kind of options:

- call option (left panel of Figure 25)
- put option (right panel of Figure 25)

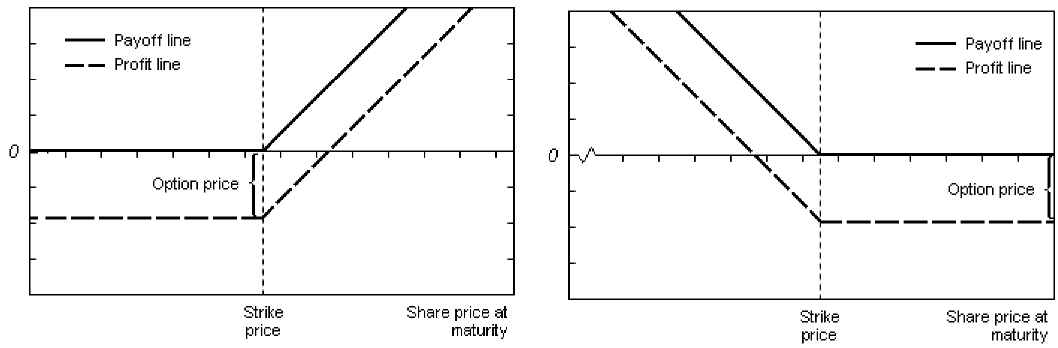


Figure 25 Payoff and profit line for long call (left) and long put (right) option

A call option speculates on an increase in the value of a stock. If the value of the stock is higher than the strike or execution price the call option has a value. The profit of a call option on execution is:

Profit = Share price at maturity – Strike Price – Option price (6.1)

If the concept of the financial options is extended to fixed assets and projects, real options are obtained. A real option therefore is the right to generate free cash flows in the futures as a result of a business decision, such as a capital investment. However the holder of the real option is not obligated to invest. An important distinction is that the fixed assets or projects, on which the real option is based, are not traded on the market.
In general three main types of (investment) options can be distinguished. By choosing for an option, future choices and cash flows arise caused by the specific option. Therefore many investment decisions can be described as a set of the three main types of options:

- option to invest immediately
- option to invest later
- option to cancel the investments

For the valuation of real options three methods are described in literature:

- Black-Scholes model
- Decision tree and Influence diagrams
- Binomial or multinomial tree
- Numerical simulation of real options

In the next paragraphs the application of the first three methods are discussed briefly. The last method relies on software packages combining a monte carlo analysis with the first three methods. The numerical simulation of real options is not discussed in this thesis.

7.4 Black-Scholes model for financial options

The value of an option equals the sum of

- The value of an asset, if the option would be executed. The value of the asset is the sum of all discounted cash flows at maturity. This depends on the price of the asset today multiplied by the chance that is exceeds the strike price at maturity.
- The value of the cash to buy the option. This value is determined by the chance that the value of the asset is higher than the strike price multiplied by the strike price itself. The expected cash flow at maturity has to de discounted back to the present.

This concept for valuation of both financial and real options is the basis of the Black-Scholes model (Black, Scholes, 1973, [2]). The Black-Scholes model quantifies the value of an option C(S,T) as:

$$C(S,T) = S \cdot \Phi(d_1) - Ke^{-rT} \cdot \Phi(d_2)$$
$$d_1 = \frac{\ln[\frac{S}{K}] + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \qquad (6.2)$$
$$d_2 = \frac{\ln[\frac{S}{K}] + (r - \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

Where

C	= Value of option
S	= Price of asset
K	= Exercise prices
r	= risk-free interest rate
ɸ	= cumulative normal distribution function
T	= Time to expiry
σ	= volatility

The Black-Scholes model has three important underlying assumptions listed by Wang (2005, [64]) :

- There are prices for the asset
- The market is efficient and provides no riskless arbitrage7 opportunities
    - Short selling of securities has no limitations
    - No transaction costs
    - All securities are perfectly visible
    - Security trading is continuous

---

[7] Arbitrage is the mechanism to earn a profit without taking any risk. According to *The law of one* price assets or a replicating portfolio of an asset, which bears the same risk and expected profit, should both be priced the same. If this would not be the case a profit could be earned risklessly by shortselling of the high-priced asset and buying of the low-priced asset. In well functioning markets these activities would eliminate the price difference ensuring the no-arbitrage principle.

- Risk free interest rate is constant and the same for all securities

C.I. In this model the value of the underlying asset S is described as a geometrically Brownian motion. The geometric Brownian is generally applied to stochastic processes of assets which are traded daily. The stochastic differential equation for modeling of the underlying stochastic asset St follows:

$$dS_t = \mu S_t dt + \sigma S_t \, dW_t \qquad (6.3)$$

With the analytical solution

$$S_t = S_0 \exp((\mu - \frac{\sigma^2}{2}) \cdot t + \sigma \cdot W_t) \qquad (6.4)$$

With:
Wt = Brownian motion
μ = constant drift
σ = volatility

Following from this the stock price at the end of a finite interval is log-normal distributed. The option valued with this formula is a European option, meaning it can only be executed at maturity. Next to this the option pays no dividend. To adjust for the payments of dividends (δ) the formula has been adjusted by Merton (Merton, 1974, [37]).

$$C(S,T) = Se^{-\delta T} \cdot \Phi(d_1) - Ke^{-rT} \cdot \Phi(d_2)$$
$$d_1 = \frac{\ln[\frac{S}{K}] + (r - \delta + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \qquad (6.5)$$
$$d_2 = d_1 - \sigma\sqrt{T}$$

With:
δ = payments of dividends

Key levers of financial and real options

In the Black-Scholes model we can identify from formula 6.5 the variables that influence the value of an option. As described in [33] these are:

- Stock Price (S) is the value of the asset. This is the market's expectation of the future cash flows. In real option theory it is the present value of all the cash flows that can be expected if invested in the project or fixed asset.
- Exercise price (K) is the price at which the option can be exercised. For real options this would be the fixed costs of a project.
- Uncertainty of price movements (σ) is the standard deviation of the growth rate of the future cash flows. If the present value of the expected cash flows is determined using probabilistic cost estimations, the uncertainty here follows from external events that change the cash flows (such as policy change or new technologies).
- Time to Expiry (T) is the period in which the option can be exercised. The real option equivalent is the time-span over which the investment decision can be postponed.
- Dividends (δ) in financial markets are comparable with the value of the option that diminishes over the period the option is valid. This includes all actions that lower the value of the cash flows in the future.

- Risk Free interest rate (r) is the interest rate on a risk free security with the same maturity as the option.

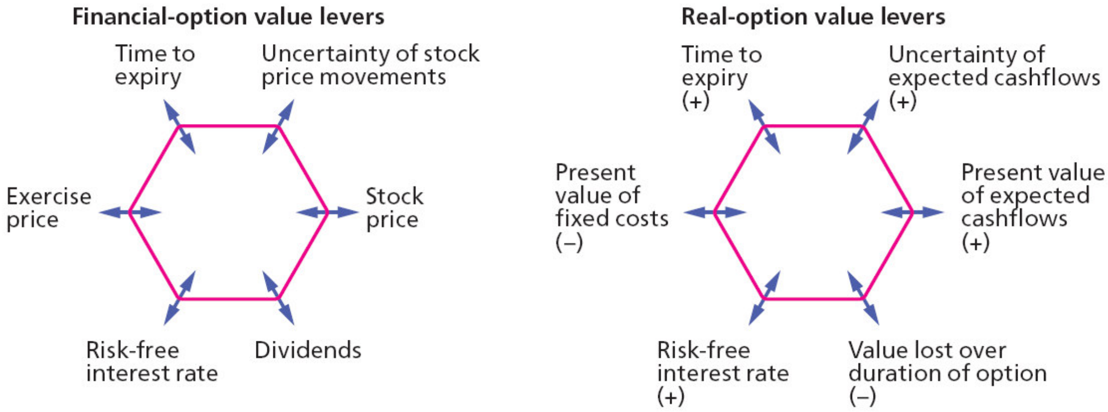


Figure 26 Analogy between financial and real options [33]

7.5 Decision Tree Analysis (DTA)

Decision Tree Analysis is a valuable tool for the steering of projects reactively, proactively and reversely,. The use of DTA for Net Present Value calculations was first described by Magee (1964). In a decision tree the different possible decision roadmaps of an investor's strategic options could be shown. By mapping these roadmaps an overview can be obtained of the possible outcomes and the decisions that lead there. The DTA could be applied whenever situations in projects arise in which uncertainty plays a role and future decisions have to be made which react or anticipates on new information.

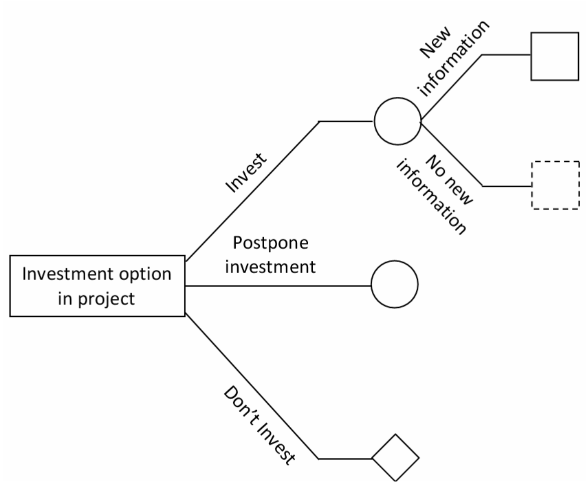


Figure 27 Example of a real option in a decision tree

A decision tree, as shown in Figure 27 contains three basic elements:

- Decision nodes (square/rectangle) shows the decision points in the project. These are project internal points which determine the course of the project. At these points the NPV of each option from that stage on, can be determined.
- Chance nodes (circle) show the points in time where external events or states of nature take place. Based on these points new information may become available. The possible new information can be used as input for a new decision in a decision node.
- Terminal nodes (diamond) are the points in the project, at which a path of the project stops. These points are accompanied by the value of the NPV of that path.

If multiple decisions are placed in sequence a decision tree of a project or an option can be obtained. Based on new information in the course of the project, new and better informed decisions can be made.

A first calculation method to take into account the course of a project and the possible flexibility in the project is using the decision tree. An example for a fully automated parking garage is shown below (see figure X). Each node splits up in two or more branches. Each branch has a conditional probability of occurrence. By calculating back from the end of the tree the expected value of the project is retrieved. The formula for calculating the expected value is given by:

$$ENPV = \sum_{i=1}^{n} p_i \sum_{t=1}^{T} \frac{DCF_{t,i}}{(1+r_d)^t} + p_n \sum_{j=1}^{m} q_j \sum_{t=1}^{T} \frac{CCF_{jt}}{(1+r_c)^t}$$

With:

pi = conditional probability of not continuing the project

DCFti = discounted cash flow of the cost over t and phase of not continuing

rd = interest rate during development

rc = interest rate during commercial phase

q = probability of occurrence of each scenario

CCFjt = commercial cash flows in scenario j at time t= discounted cash flows from revenues-OPEX

An graphical example is given in Figure 28. The value at the end of each branch can be calculated with the formula at the end of each branch. Depending on the path leading to the end of the branch, the values of the parameters vary.

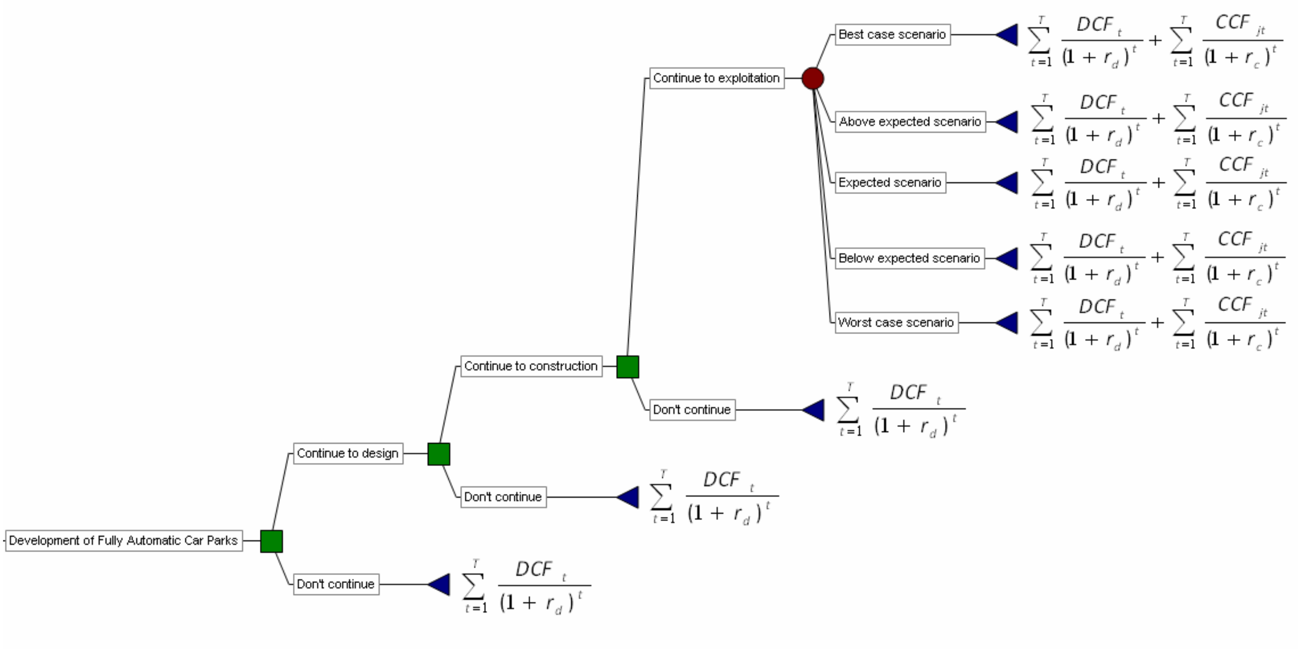


Figure 28 Example of a decision tree

7.6 Binomial or multinomial tree

In the model another method is applied to value the flexibility in the project. The inclusion of real options in the project can be modeled by using a multinomial lattice. In this project a binomial lattice is applied, having two options at each node. Examples of the application of the binomial and trinomial lattice method are given by Kellogg et al. (1999, Valuation of a Biotechnology Firm: an application of real-options methodologies), Zhao and Tseng (2003,) and Chiara et al. (2007,) The valuation of a project using the binomial lattice method consists of multiple calculation steps. These steps are applied in the model.

1. An uncertain parameter in the boundary conditions is identified. In this thesis external demand is chosen as parameter. The revenues in the exploitation phase depend on the demand.

2. Multiple scenarios (j=1 …n) are generated in which the uncertain parameter is varied. These scenarios generate different outcomes for the modeled cash flows. The probability of the occurrence of each scenario is assumed to have a fixed value (pj=1…n).
3. In each scenario time steps are identified, on which a decision can be taken on the continuation or alternation of the project. The chance of continuation from phase t to t+1 is ϴt.

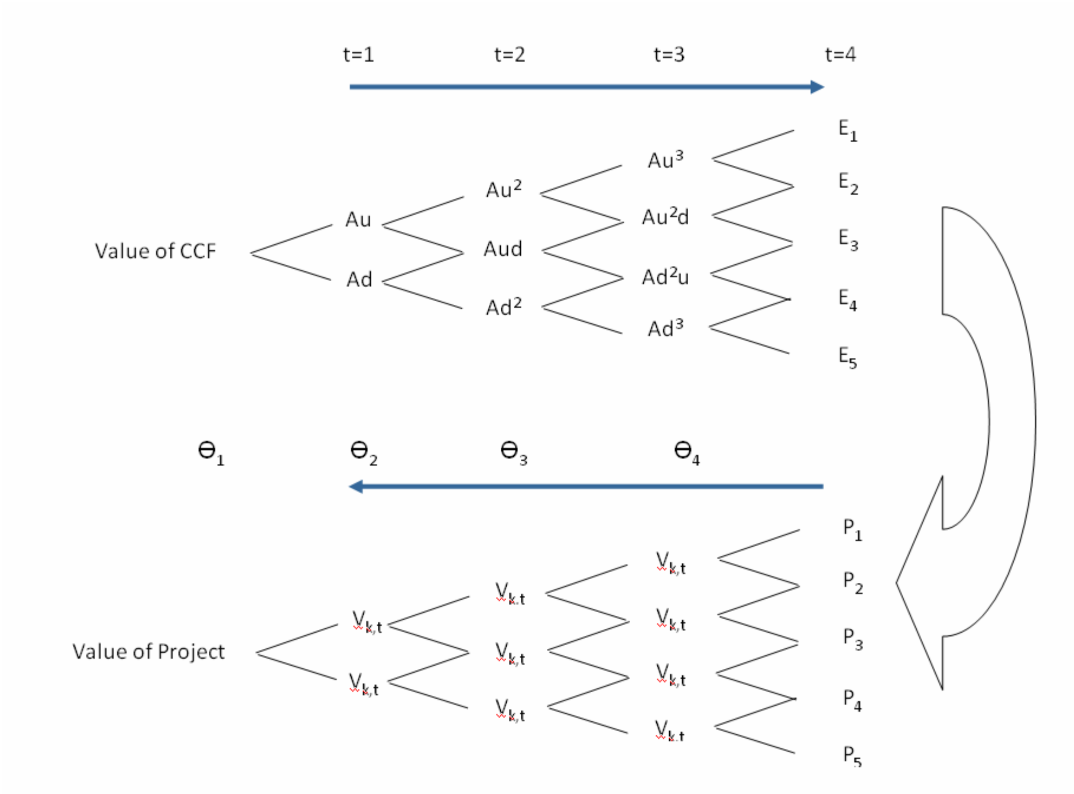


Figure 29 Calculation scheme of a binomial lattice (symbols explained in this section)

4. A binomial lattice is constructed (see Figure 29)). The top value of the tree in the upper panel is the asset value (Value of CCF; A) of the expected commercial cash flows of the different scenarios, multiplied by the probability of each scenario. The steps of the lattice are calculated with the volatility of the commercial cash flows (σ). The volatility is calculated by dividing the expected commercial cash flow in the best case scenario by the asset value. This value is adjusted for the number of steps in the lattice. This multiplication factor on the outcomes for an upward development (u) of the uncertain parameter and in a downward movement (d). At the end of the lattice the different possible outcomes of the binomial tree are described by Ek. The values in the lattice are given by the formulae:

$$A = \sum_{j=1}^{n} \left(p_j \sum_{t=1}^{T} \frac{CCF_{jt}}{(1+r_C)^t} \right)$$

$$h = \max \left\{ \sum_{t=1}^{T} \frac{CCF_{jt}}{(1+r_C)^t} (1+r_C)^l \right\}$$

$$\sigma = \ln(\frac{h}{A})^{\frac{1}{l}}$$

$$u = e^{\sigma\sqrt{\Delta t}}$$

$$d = \frac{1}{u}$$

With:
A = Value of Commercial Cash Flows
pj = probability of scenario j
CCF = Commercial Cash Flows = Revenues – Opex
rC = discount rate in exploitation phase
l = time until end of binomial lattice. The end of the binomial tree is eventual outcome of each scenario
σ = volatility in uncertain parameter of the boundary condition
u = multiplication factor of the outcomes for an upward movement
d = multiplication factor of the outcomes for a downward movement

5. After the event tree is constructed, a second tree is constructed: the payoff tree (see Figure 29 lower panel). Starting at the back, the project value is calculated that corresponds to the different states shown in the upper panel. Using the risk neutral probabilities of each branch, the project value at t=0 can be calculated. The expected payoffs at each node can be calculated with:

$$P_{k,t} = Max\left[E_k(\theta_t) - DCF_t, 0\right]$$

With:
Pk,t= payoff at node k at time t
Ek= Event states of different outcomes
Ѳt= conditional probability of going from phase t to phase t+1
DCFt= discounted cash flow of costs in period t

6. Between two nodes the payoffs are rolled back to the overall value. This is done by using the risk neutral probabilities that correspond to u and d in the upper tree:

$$p = \frac{e^{r\Delta t} - d}{u - d}$$

$$q = 1 - p$$

$$V_{k,t} = Max\left|(V_{k,t+1}p + V_{k,t+1}q)e^{-r\sqrt{\Delta t}}\theta_t - DCF_t, 0\right|$$

With:
r = risk free interest rate
Vk,t= Value at node k at time t

This calculation is repeated until the start of the payoff tree (see figure, lower tree). That value at the top displays the value of the project as a real option using the binomial lattice. The multinomial lattice works similarly, however having multiple branches per node. The calculation approach is the same.

7.7 Discussion on the application of option pricing in real markets

Much discussion exists on the application of the option pricing theory on fixed assets. In many publications is argued that the underlying assumptions of the option pricing theory (see paragraph 7.3) do not or partially hold for real assets (Wang and Neufville, 2005, [63]).

- Primarily in real markets not all assets have a market price. Secondly the prices of some real assets are not transparent or visible. In civil engineering practice the price of a project is generally determined by the tender process and does not have a market price. Thirdly the determination of volatility for real options can be difficult. In market traded assets the volatility is given as the variance of the stock price. However the volatility of real assets without listed prices is practically impossible due to a lack of information

- The no-arbitrage argument is difficult to prove for real assets. A replicating portfolio for real options with the same risk and payoff is hard to construct. With a replicating portfolio of a real asset the prices could directly be observed in the market. Since it is not possible to construct a replicating portfolio for most of the real options, the no arbitrage argument is hard to hold. Secondly in large projects the option of shortselling the real option is not present. Therefore the correcting mechanism of the no-arbitrage principle is not present. In some literature it is argued that the risk-adjusted interest rate should be used to replicate a real option with stocks with the same expected payoff and therefore the same risk adjusted interest rate.
- The model assumes a Brownian motion. This is a stochastic process which is generally used for daily traded assets with volatile prices. However the application of this assumption in civil engineering can be argued. Some components of a project do not show a log normal distribution. Secondly the Brownian motion assumes a constant growth rate. The Brownian motion can be applied to fluctuations in commodity prices, however for real options the Brownian motions does not seem to be the best stochastic process. The application of Brownian motion on real estate was discussed by Kuo (1995,[31])
- In this standard real option model the right to the investment opportunities is assumed to be exclusive (Black, Scholes, 1973). In competitive markets this assumption does not hold, since the action of one player can affect the actions of the other. In civil engineering practice some situations show competitive markets and some do not. Exclusive project rights do exist, once the project is granted. However in the case of project development without exclusive contracts competition should be included. The interaction between competitors on real estate markets was studied by William (1996, [65]), Grenadier (1996, [26]), Smit (2003, [58]) and Wang and Zhou (2006, [62]). The influence of the type of competition was discussed by Smit and Trigeorgis (2001, [59]). Critical point in the use of real option theory was the possibility of optimal timing of the investment under uncertainty. Wong (2006, [66]) discussed the influence of parameters to the execution time of real options, such as volatility, discount rates and growth rates.

From the above it follows that the model of Black & Scholes is not directly applicable on the valuation of real options in general. However the formula gives a useful framework for analyzing the levers of real options. In the literature many argue that the usefulness of real options lies in the thinking that uncertainty also offers opportunities and the value of reacting on future boundary conditions. (Cardin & al., 2007, [7]; Leviakangas, 2007, [34]; Zhao & al., 2004, [67]; Wang and Neufville, 2005, [63])

Wang and Neufville (2005, [63]) recognized this opportunity by dividing the real options in two categories:

- Real options "on" projects focusing on the valuation of the project or fixed asset itself
- Real options "in" projects focusing on the flexibility of the project internally. The identification of real options in for example a design required technological insight in the technology used.

The differences in focus between real options "on" and "in" projects are summarized in Table 3.

Real options "on" projects	Real options "in" projects
Value opportunity	Flexibility of design
Valuation is important	Decision making is important

Relatively easy to define	Technical insight needed to define
Interdependency/path dependency less of an issue	Interdependency/Path-dependancy an important issue

Table 3 Characteristics of real option "on" and "in" projects

With the real option on projects it should be considered whether the traditional option pricing theory holds. The Brownian motion and no-arbitrage assumption could hold for commodity prices or land prices, which are a part of the project valuation. For total projects the legitimate application is harder to prove.

Real options "in" projects are options in the design or process which can influence the outcome of the project by adapting to the boundary conditions in a later phase. By leaving a reservation in the design the project owner is able to react on future changes in the boundary conditions. The real options in a project can be discovered when the design and the uncertainties are investigated more closely. Applying the real option theory in the design requires technological insight. The valuation is less straightforward since the Black-Scholes assumptions do not hold. Real options deal with uncertainty in the boundary conditions on the one hand and the effect of this on a design parameter on the other hand. By fitting the design parameter when the boundary conditions change favourably, a more efficient solution is found and the expected return is maximized. How the value of real options can be extracted from uncertainty in the design process was described by Cardin (2007, [7]).
The implementation of such options was done more frequently. However theory on how these options were valued and taken into account in the cost estimation remained less detailed. In theory some applications of real options in projects were described. Smit (2003, [58]) discussed the real options for an airport expansion. Zhao and Tseng (2003, [68]) described the valuation of real options in a multi-storey parking garage. This approach was extended by Neufville, Scholtes & Wang (2006, [48]) on how to implement the valuation in spreadsheet programs. Zhao, Sundararajan and Tseng (2004, [67]) consequently used a similar approach for highway development. Another approach was described by Chiara et al. (2007, [8]) for infrastructure in PPP projects. Leviakangas and Lahesmaa focused on real option valuation for toll roads (2002, [35]). The value-for-money of flexibility in hospital infrastructure was described by Neufville, Lee & Scholtes (2008, [47]).

7.8 Advantages of Real Option Analysis (ROA)

Often insufficient attention is paid to the way how decision makers… can increase opportunities for upward potential of future options and include them in the valuation. Smart anticipation on these options and uncertainties will result in a higher value of the project.[8]

The Real Option Analysis (ROA) includes the possibility to translate the uncertainty over the projects course into the project valuation. In the Net Present Value method the valuation takes place from a priori point of view. Thereby this method assumes different scenarios that can develop during the project by making decision on new information. In contrast real option analysis includes the follow-up of decisions in a project. With each decision the project can reactively respond to the new information that becomes available. With the reactive flexibility better informed investment decisions can be made at an optimal timed moment. Therefore, the flexibility of a project creates opportunities for the project company to increase the value of a project over its duration. The ROA values the NPV plus the expected change in NPV over the option's life time [33].

[8] Rhee, G. van, 2006. Kan een maatschappelijke kosten-baten analyse worden gebruikt voor de beoordeling van innovatieprogramma's?

Next to this reactive approach to information, the flexibility in the project can also be used proactively. This can be done primarily by recognizing that future phases depend on outcomes of previous ones. A project can be planned in order to maximize the value of the option if this fact is understood. Counter intuitively this means that greater uncertainty of the project means a larger value of the option. This can be explained by the fact that greater uncertainty also increases the number of decisions possible to optimize the project return.

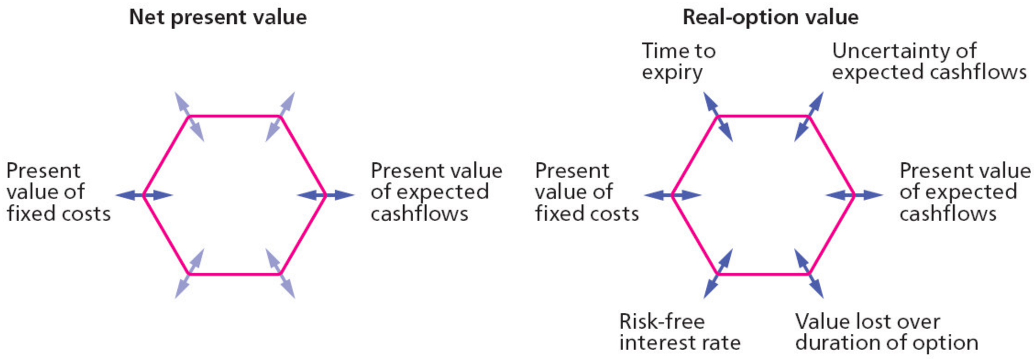


Figure 30 Comparison of factors considered in NPV valuation and the Real Option valuation[33]

Secondly the value of a project can be maximized by the steering of projects on the available information or timing of the availability of information. Therefore the project can be steered proactively by optimizing the timing of the reactive decisions. By reducing the largest risks before certain milestones, negative contributions to the NPV of a project can be minimized.

By considering the outcomes of different scenarios of the real option analysis, a projects expected value and sensitivity can be analyzed reversely. In early phases the most important key factors of a projects value can be recognized by analyzing the expected outcomes of each option. Project dependant variables can also be calculated and evaluated, looking back from the potential outcomes towards the possible options. For example, the required r_{WACC} or risk minimizing strategies can be determined given a certain set of scenarios and possible outcomes. Considering the amount of available information in each stage of the project the r_{WACC} can be adjusted towards the risk of the project. In this way the financing structure can be optimized.

In this chapter…

In the standard Discounted Cash Flow methods flexibility and strategic decision can not be taken into account. Using Real Option Analysis the value of flexibility can be included in the valuation. Real option theory is derived from the financial option theory. The application of real option valuation can be a useful addition to standard valuation methods.

For the real option valuation three methods are available:

The Black-Scholes model, which is used for the valuation of financial options.

Decision Tree analysis

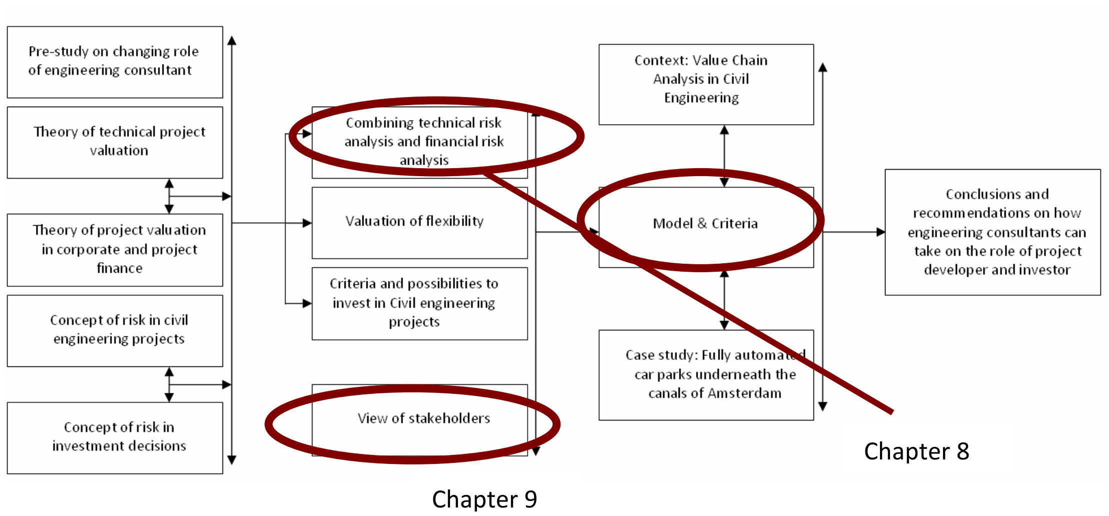
Binomial or multinomial Tree analysis

The best method is the real option valuation using the decision tree analysis. This method for real options in projects forces the identification of future decision points, it values and maps project scenarios and facilitates possibilities to anticipate on changing boundary conditions and to take advantage from opportunities that may arise from these changes.

The Black-Scholes model can not be applied to real option valuation, since the underlying assumptions of the model do not hold for real options. The binomial tree analysis is less useful because it does not take path dependency into account and because civil engineering projects show a less clear phasing.

PART III: PROJECT VALUATION MODEL

The research objectives are investigated using an excel model, which simulates the cash flows of the project. In the model both the cash flows in the construction phase and in the exploitation phase are simulated using a probabilistic approach. Including the financing side of a project the model results in a estimation of the financial and commercial feasibility of the project. In chapter 8 the model is described. The objectives of the model are discussed, the components of the model summarized and the approach for validation described. In chapter 9 some opinions of stakeholders are given on the valuation of flexibility.
The model is designed to deal with the construction and exploitation of civil engineering constructions in general .The general setup can be applied for all PPP and hybrid projects. This model is applied to fully automated car parks. The project specific input is In part IV the specific input for car parks is described in more detail.



8. VALUATION MODEL

8.1. Introduction

Central part of this research is the development of a valuation model in which both the civil engineering side and the financial side are jointly considered. Using the model the relation between technical and financial parameters and the effects on each other can be investigated. In this model the cash flows of the projects are modeled. With the model Monte Carlo simulations can be done in order to get insight in the uncertainty of the parameters and the various outcomes. The model is applied to the case study described in part IV. In appendix XII a brief manual of the worksheets of the model is given in order to give some insight into its functionality.
In section 8.2 the general model setup is described. In this section the objectives of the model and the structure of the model are described. Section 8.3 discusses the modeling software which is used. This section also explains the actions the model does during an iteration of the simulation. The rest of the chapter (section 8.4 – section 8.8) presents the formulae used in the model and the calculations that are done. The central part of the model is the cash flow overview (section 8.4). The calculations done in the underlying worksheets are given in section 8.5. The last three sections cover the calculations on the outside layer of the model (see figure 31). In these sections the calculation that are made for the sensitivity analysis (section 8.6) and the valuation of flexibility (section 8.7) are presented. The last section gives a brief description on how the calibration and validation of the model is done (section 8.8).

8.2. General model setup

To investigate the attractiveness of developing of civil engineering projects and investing in those projects, a model has been constructed in Excel. With this model the commercial and financial feasibility can be researched by simulating the course of a project. The model has three main objectives:

- Researching the (commercial) feasibility of the project
- Offering insight in the key levers and key risks of the project
- Investigating the application of real options in the project valuation

This model is made in order to be applied on civil engineering projects in general, ranging from infrastructure projects tendered by the government to application with a more market oriented character, like car parks. The cash flow structure is similar for all these projects. However for each project the model needs zooming in on the project specific input and characteristics. The model setup in this study is focused on a specific project. For other car parks this model can be applied directly, taking the local and design parameters as input. For civil engineering projects in general the project specific input should be adjusted.

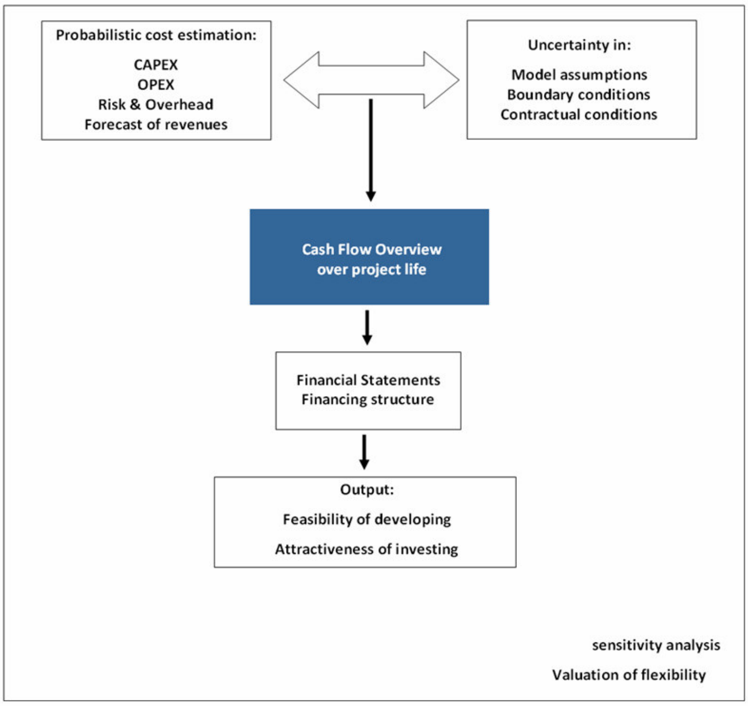


Figure 31 Setup of model

To investigate the feasibility as a project developer and equity investor, the model consists of four components. . The relations in the model are shown in Figure 31.

- Probabilistic cost estimation; The probabilistic cost estimations focuses separately on the CAPEX, OPEX, risks and revenue forecast of the project. This analysis results in an insight of the spread around the expected outcome. The cost estimation is based on model assumptions and boundary and contractual conditions.
- Financial Base model; the financial base model is included to simulate the financial structure of the project. This part translates civil engineering risk into investment risk and the effect on the project valuation.
- Sensitivity analysis; the level-II sensitivity analysis is done to gain more insight in the project parameters. With this analysis the sensitivity of the project outcome can be linked to the parameters. This results in the determination of criteria for the successful developing of projects and investing in them.
- Valuation of flexibility; the effect of the valuation of flexibility is modeled with a binomial lattice, decision tree and simulation of events.

Each of these components is discussed in the next paragraphs.

The project cash flow based on the project's assumptions and boundary conditions are represented in de cash flow overview. This overview is the central part of the model. Based on the cash flow overview the financial statements can be formed. With the financial statements and the expected cash flows, the financing needs can be determined. The total output is generated combining these statements and the cash flow overview. Both a leveraged as e an unleveraged structure can be analyzed. This thesis focuses on the study of project parameters that determine the attractiveness of developing and investing. Secondly the valuation of flexibility in the project is studied in the model. The flow of information through the model is shown in Figure 31.

The projects characteristics are summarized in the probabilistic cost estimation of the costs and the revenues. The costs are divided in CAPEX, OPEX and Risk & Overhead. In the model is chosen to use these definitions since they cover the meaning better than the commonly used term (e.g. Construction costs, Exploitation costs)

- In the CAPEX all the construction costs and developing costs are included that are needed to realize the car park. This also includes the costs for maintenance the construction to be able to fulfill the needs for exploitation
- In the OPEX all the costs for exploitation of the construction are listed. This includes the general maintenance costs for exploitation specific components.
- The risk and unforeseen part includes to separate reserves for risks and surcharges for overhead.

The cash flows in each of the four sections are modeled based on the stakeholder overview shown in . The cash flows are modeled from the point of view of the SPV/SPC. In the model the equity investor is seen as a external part. In practice the equity investor and SPV/SPC are combined.

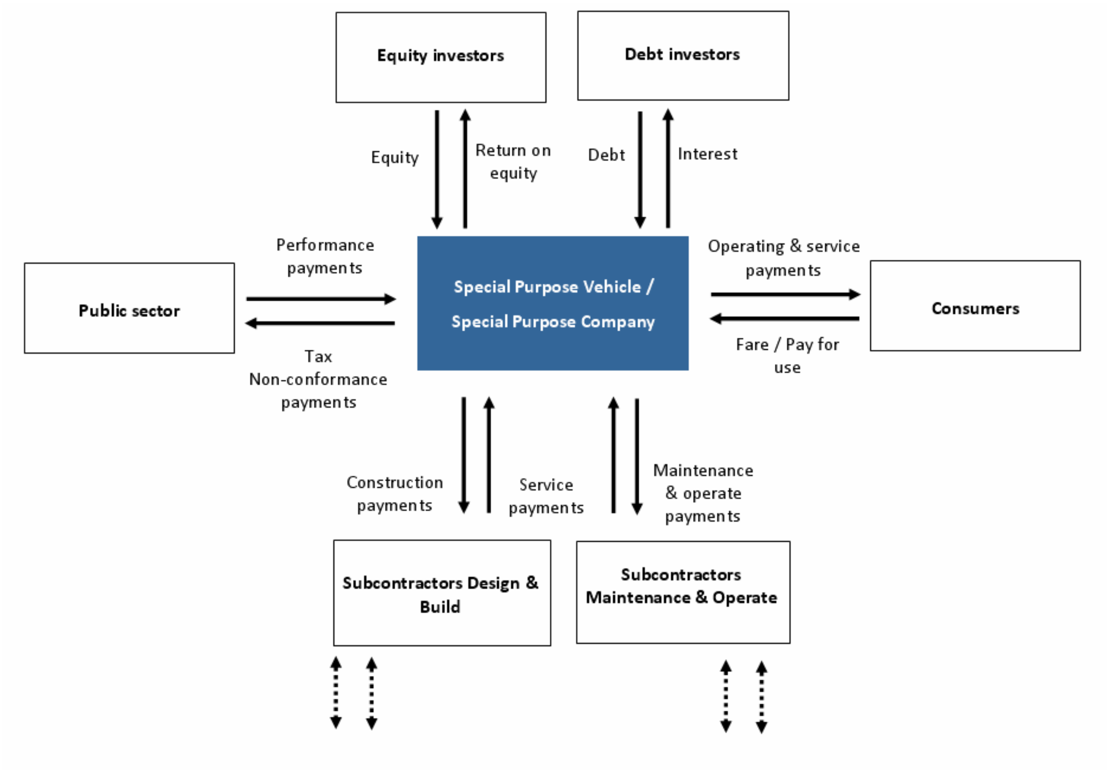


Figure 32 Overview of cash flows in a project

8.3 Model software

The model is programmed in Microsoft Excel using the plugin At Risk and Precision Tree and programming software in Visual Basic. Commonly numerical optimization problems are programmed in Matlab. Matlab has powerful data handling, insightful programming and good output graphing. However due to the increasing numerical power of desktop computers, the need for powerful calculation programs has decreased. The reasons for choosing Excel/At Risk over Matlab are:

- Better overview of calculation results
- Graphical interface
- Better compliance to third persons
- Higher compatibility with customers and partners
- Cheaper license cost of software

A disadvantage of the Excel/At Risk software is the difficulty of validating a model. Due to the cellular setup of the program, the formulae give less insight. Therefore checking the correctness and applicability of the model is a concern. To meet this objection the next measures are included in the model:

- Structured setup of the worksheets according to general accounting principles
- One worksheet containing all the model assumptions
- Validation by multiple expert opinions (see section 8.8)

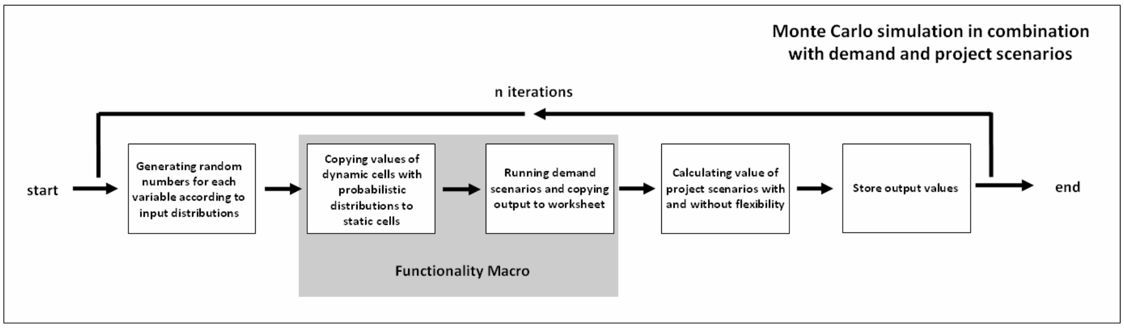


Figure 33 Monte Carlo simulation in combination with demand and project scenarios

The Monte Carlo analysis and the modeling of standard distributions are done by the Excel-plugin At Risk. For theoretical background on these topics and exact programming, one is referred to other sources. Numerous literature and examples exist for these optimizations as a result of the wide applications in practice. For scenario analysis macros are used. Macros are programmed in Visual Basic. In Figure 33 the simulation process of the Monte Carlo analysis and the simulation of the demand and project scenarios is shown. The description of the demand and project scenarios is described in section 8.5.

8.4 Cash Flow Overview

The cash flow overview is the central part of the model. The cash flows are modeled at six-month interval over the project's life span. The project's life span is variable with a maximum length of 41 years, including construction time. The change in cash is calculated based on the next three formulae:

$$\text{NOI} = \text{Net Revenues} - \text{CAPEX} - \text{OPEX} - \text{Risk \& Overhead} - \text{WC} - \text{Financing costs} \quad (8.1)$$

$$\text{OCF} = \text{NOI} - \text{Budget overruns} - \text{Tax} + \text{Extraordinary Sales} \quad (8.2)$$

$$\text{Change in Cash} = \text{OCF} - \text{Interest payment} - \text{Debt Repayment} - \text{Funding} \quad (8.3)$$

With
NOI = Net operating Income
CAPEX = Capital Expenditures
OPEX = Operational Expenditures
WC = Working Capital
OCF = Operating Cash Flow

The required capital is determined by formula (8.3). Financing is needed if:

$$\text{OCF} - \text{Interest Payment} - \text{Debt repayment} < 0 \quad (8.4)$$

In the start phase of the project, the funding consists of debt and equity. In later stages, when revenues are generated by the project, funding of expenses and operational risk is covered by equity. The cash flow to equity in each period is given by:

Cash flow to equity = OCF – Debt service – Debt drawn (8.5)

Debt service = Interest payment + Debt repayment (8.6)

The result of a project can be calculated by the net present value of the free cash flows, as given in formula 4.1. For the leveraged case this is done by discounting the cash flow to equity. For the unleveraged case this is done by discounting the operational cash flow.

8.5. Project input

CAPEX & OPEX

The input for capital expenditures and operational expenditures are calculated with formula (8.7) as given by Vrijling ([78]). In probabilistic cost estimation a probability distribution is taken for both the amount and the price of each expenditure or revenue. The total estimation of the CAPEX and OPEX can be calculated with the last part of formula 8.7. The addition of a_j for overhead is discussed in the next paragraph.

$$C = \prod_{j=1}^{m}(1+a_j) * \left\{ \sum_{i=1}^{n} q_i * pr_i \right\} \quad (8.7)$$

With
q_i = probability distribution for the amount of portion i
pr_i = probability distribution for the price of portion i
a_j = surcharge factor for overhead

Each cost item has a duration which is a statistical variable as well. For the distribution of the duration of each construction part a triangular distribution is taken. The lowest, mean and highest possible value are taken as the 5%, 50% and 95% values of the distribution.

Risk and overhead

Reserves for risk and overhead are combined. Risks and overhead surcharges also are assumed to have a probability distribution. Overhead surcharges are calculated as a percentage over the CAPEX (see formula 8.7: 1+a_j). The risks and their costs follow from the technical risk assessment. The risks are added to the other cost components. After this, risk and overhead can be assigned to specific periods.

Revenues

The revenue of the project is calculated by adding the revenues of the licenses sold and the revenues for visitor parking. The revenues can be calculated for each period with formula (8.8). Next to this calculated revenue, a subsidy is given per parking space. This is however not included in the model.

$$\begin{aligned} R_{licenses} &= C_{license} \cdot r_{constructed} \cdot r_{available} \cdot r_{sortlicense} \cdot \frac{X_{license}}{X_{total}} X_{planned} \\ R_{visitors} &= C_{hourly} \cdot t_{operational} \cdot r_{constructed} \cdot r_{available} \cdot r_{occupation} \cdot \frac{X_{visitor}}{X_{total}} X_{planned} \end{aligned} \quad (8.8)$$

With
R = total revenues
C = parking fee

$r_{constructed}$= reduction factor for portion of parking spaces completed
$r_{available}$ = reduction factor for portion of parking spaces that is mechanically available
$r_{sort\ license}$ = ratio of specific sort of license of overall licenses (full license, resident license and office license)
$r_{occupation}$= occupation rate of visitor parking spaces
$t_{operational}$= operation time of the car park
X = total number of parking spaces

The total number of parking spaces is reduced by the number of parking spaces needed for the mobility of the system. In the model this is set to 1 space per 16 spaces.
The occupation rates vary per location, per day and per hour, as can be seen in appendix II. The specific values of the parameters in the formulae 8.8 are discussed in part IV.

Financial Statements

Both the income statement and the balance are given in the financial statement part of the model. The Income statement can be described with the formulae:

EBITDA = Revenues – Expenses
EBITA = EBITDA – Depreciation – Extraordinary loss/profit on sales
Net Income = EBITA – Interest – Taxes (8.9)
Taxes = Average corporate tax rate * EBITA
Retained Earning = Net income - Dividend

The debt repayment is assumed to be linearly over the length of the debt. The debt repayment period is determined by the length of the project minus a grace period and a period the debt is repaid before ending the project.

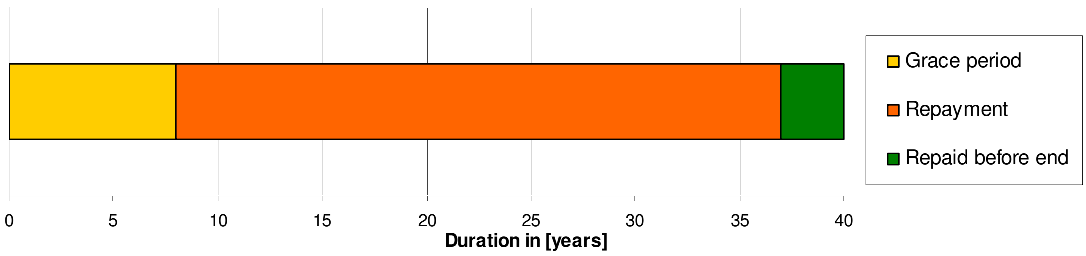


Figure 34 Example of the link between the debt repayment, grace period and end period relative to the total life of the debt

8.6. Sensitivity analysis using linear regression coefficients

The sensitivity analysis of the model parameters will be done by determining the linear regression coefficients. A sensitivity analysis is performed to get insight of which uncertainty in the input parameters cause the largest effect on the output. The regression coefficient can be determined by plotting the spread in results versus the spread of the input parameter of which the regression coefficient needs to be determined (an example of such a graph in Figure 35). The line through the data points which fits best using the least mean square estimator is the regression line. The linear regression line is in the form of y=ax+b and {a} is the linear regression coefficient. In the model most parameters have a linear relationship with the variations on the results. In the case there is a spread the datapoint can be estimated with an ellipse. The regression line fitting the ellipse best is in this case the regression line. Since in this model not all input parameters have the same unit, the regression coefficients are scaled per standard deviation in order to make comparison of each input parameter possible.

In this study the sensitivity analysis is done empirically by simulations of the model. The regression coefficients are defined to be the change in NPV per standard deviation of the input parameter. For each parameter the variations in NPV are plotted versus the random generated numbers of the input distribution. Per simulation all other uncertainties in parameters are set to 0. In the output cloud of data, the linear regression line can be determined going through all data points with the least mean square method vertically on the Y values. With the linear regression line the linear regression coefficient can be identified. In this analysis it is assumed that all parameters are independent. The graphs of the spread on results versus the spread of the input parameter can be obtained from the model and At Risk.

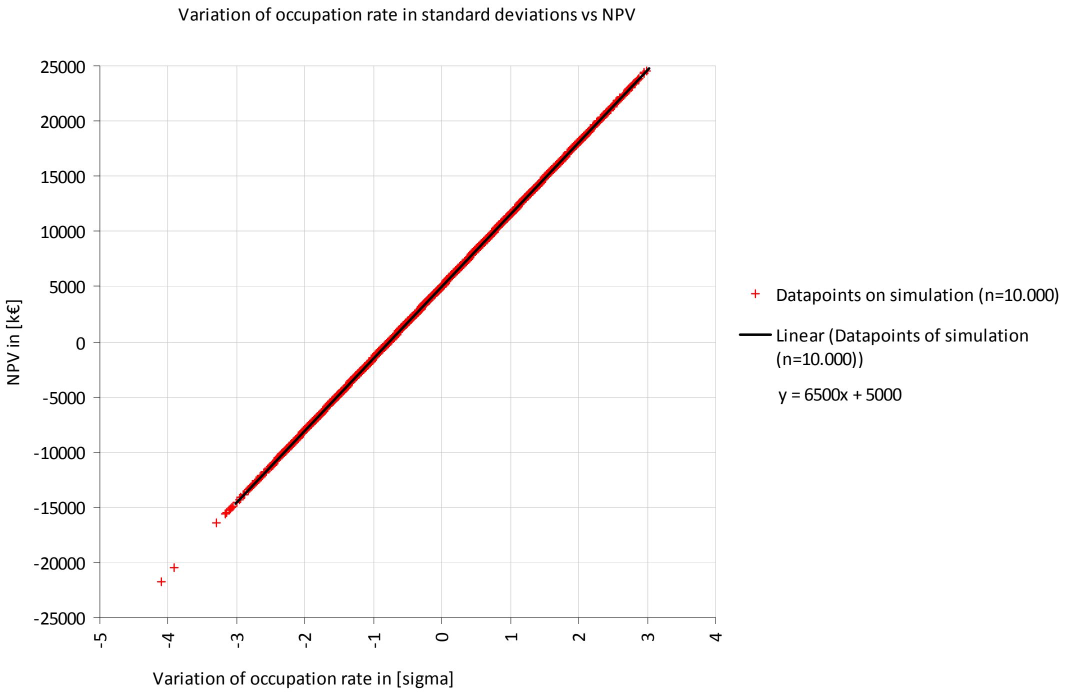


Figure 35 Example of determination of regression coefficient (occupation rate)

8.7. Valuation of Flexibility

The last component of the model covers the valuation of flexibility in the project (see Figure 31). Three different flexibility valuations are considered.

- Valuation of flexibility with a decision tree
- Valuation of flexibility with binomial tree
- Valuation of flexibility of risk allocation

For the valuation of flexibility, the project is divided into seven phases. The phases are listed in table 3. The time frame of each phase is in half years from the start of the project.

Phase	Half year	
1	1st	Engineering and preparations
2	2nd – 3rd	Construction part I
3	4th – 5th	Construction part II with function specific adjustments
4	6th – 7th	Exploitation year 1
5	8th – 9th	Exploitation year 2
6	10th – 15th	Exploitation year 3-5
7	16th – end	Exploitation year 6 – end of concession

Table 4 Phases in project with time frame and phase description

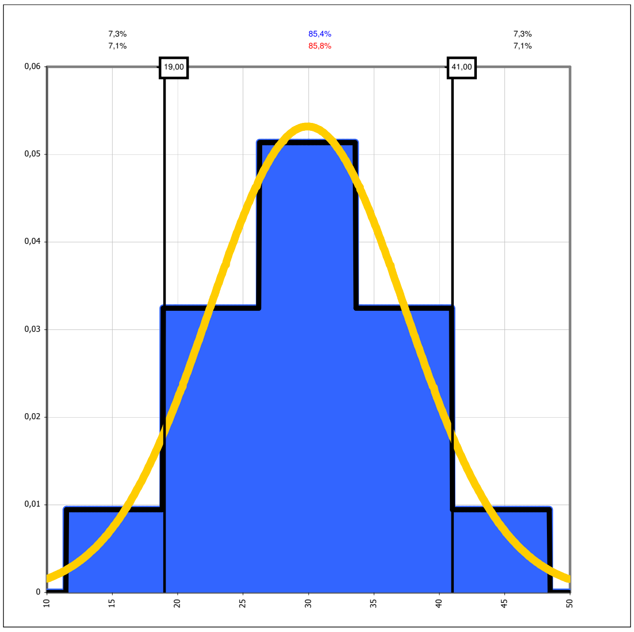


Figure 36 Approximation of normal distributed demand (yellow line) by five scenarios (five histogram bars)

The boundary condition that is taken as uncertainty value is the parking demand. Five scenarios are described: very low demand, below expected, expected, above expected and very high demand. The occupation rates used for the expected scenario are based on the research for occupation rates of car parks in city centers (see appendix II). The demand is assumed to be normal distributed. In Figure 36 is shown how the normal distribution is estimated with five scenarios. The other scenarios are deviations from the expected scenario.

8.7.1. Cases of real options

For the valuation of the real options with the decision tree analysis multiple cases are modeled. In appendix VIII the decision trees used are shown.

- Base case (see appendix VIII)
  The base case is the standard course of the project under consideration. This includes the uncertainty of winning the tender and the decision to start the project and start the construction. In the exploitation phase of the project the uncertainty in the demand is modeled with the five pre described scenarios.

- Real option of developing a second car park in phase 3 (see appendix VIII Figure 90)
  This decision tree includes the option of developing a second car park if the demand for car parks turns out to be advantageous. The engineering of the second car park starts when is decided to start the construction of the first car park. The option of constructing the second car park is after one year of exploitation of the first car park.

- Real option of developing a second car park in phase 6 (see appendix VIII Figure 91)
  This decision tree includes the option of developing a second car park is the demand for car parks turns out to be advantageous. The complete development of the second car parks starts after two years exploitation of the first car park.

- Real option of developing a second car park in phase 3 and 6

This decision tree treats the option to choose later in the project whether to start the engineering of the second car park in phase 3 or phase 6. This is a combination of the two above real options.

- Real option of alternate exploitation

  This decision tree treats the option of choosing the sort of exploitation of the construction. In the model the probability of changing parking policy by the city government is included. Depending on the parking policy the revenues vary. If the policy changes in an unfavorable way for car park exploitation a lower demand is modeled. Secondly an option is modeled after two years of exploitation of a car park. At this point there is the option to switch exploitation or to continue of the exploitation as a car park. The alternative exploitation is described in section 10.5.

8.7.2 Valuation of flexibility with decision tree and binomial tree analysis

In the model the cases of real options are both modeled using the decision tree analysis and the binomial tree analysis. The cases modeled using the decision trees are depicted and described in detail in appendix VIII. The method of decision tree analysis is described in chapter 7. In the binomial tree the same cases as with the decision tree are analyzed. However due to the method, path dependencies can not be taken into account. The assumptions made for the modeling of the binomial trees are listed in appendix IX. The methods used are described in chapter 7.

8.7.3 Valuation of flexibility in risk allocation

In appendix IV for each risk the time frame to which they are allocated is given in the last column. For example the risks of licenses that are not granted mainly fall in the preparation phase. The effect of flexibility in the risk allocation is researched by allocating the risks both at the beginning of the time frame versus a linear spread of the risk reserve over the time frame. In the base case the risk reserves were allocated to the start of the time frames in appendix IV. The results due to a different risk reserve allocation is are presented in section 12.5.

8.8 Validation and calibration

As mentioned in section 8.3 the validation and calibration of an excel model requires some effort. Errors in formulae are harder to track. A check of the correctness of the links in the model needs attention. The calibration of this model is done by making an extensive hand calculation. The results from the hand calculation are compared to the outcomes of the model. This hand calculation is made in appendix VI. For general validation the model was discussed with car park expert from Royal Haskoning, ir. J.Hus.

In this chapter…

Central part of the research is the development of a valuation model in which the technical side and the financial side of a project are jointly considered. This model is modeled in Excel and @ Risk. The structure and the formulae used are described in this chapter. The theory from part II of the report is included in the model. With the model also the sensitivity analysis and the valuation of flexibility can be performed. The real option cases that are modeled are described briefly in this chapter.

9. OPINION OF STAKEHOLDER: VALUATION OF FLEXIBILITY

9.1 Introduction

In the model the valuation of flexibility is investigated quantitatively. To gain insight into the qualitative and practical aspects of the valuation of flexibility interviews were conducted. In this chapter the results from these interviews are presented.
In the interviews 4 questions were addressed:

- What is the current practice for project valuation from the stakeholders' point of view?
- What are the characteristics of flexibility that is included in the projects?
- What could be difficulties of applying real option analysis in practice?
- What are criteria for applying real option analysis?

The stakeholders that were interviewed in this study are listed below. The opinions given do not represent official opinions from the representing departments.

Name	Institution
Dhr. P. van Marken	Dutch Ministry of Finance; department PPP
Dhr. G.J. Zyp	De Key real estate

9.2. Opinion of stakeholder on valuation of flexibility

9.2.1. Current practice of including flexibility in civil engineering projects

Possibilities to include flexibility are largely influenced by the current practice of tendering civil engineering projects. The current process of tendering determines in which phase flexibility can be included in the design and by whom. How flexibility is included in the current tender process in described in the next bullet points.

- A need for a specific construction is stated by the government. Based on a cost estimation by the government a budget is reserved for the project. Both the need and the calculated cost determine the feasibility of the project.
- The government states the output requirements in an output specification, describing the minimum required specifications of the construction. In this output specification also requirements towards flexibility of the construction are stated. This is done qualitatively. These flexibilities have been identified by the ministry of finance as options, that when executed, having a high enough added value to the construction.
- In the tender procedure market parties bidding on the project have to include the required flexibility. By describing qualitatively how the required flexibility is included in the design,

bidding parties earn points in order to separate themselves from competing market parties. The points are given based on the costs of execution of the option and the qualitative realization of the flexibility in the design.

- The project is given to the market party with the lowest price. This price is a combination of both the NPV and the points for flexibility and other added functions.

From this tender process follows that mainly two parties have the ability to focus on flexibility:

- The government identifies required options and flexibility. These are included in the output specifications
- Bidding parties can use option thinking in order to minimize the NPV of the cost estimation. This can only be done as an alternative way of realizing the given required output.

The government focus on flexibility lies generally in the exploitation part of projects. Design flexibility in which technical aspects in the construction phase are left for consideration to the private parties. Valuation of the flexibility opportunities in the construction or maintenance phase is included in the bids of the market parties. The cost estimation by the public side is only used as reference and not as absolute project valuation.

9.2.2. Characteristics of including flexibility in civil engineering projects

From the tender process follow certain characteristics which determine the possibility of including option thinking in the design process. The value of designing flexible constructions is understood. In tendering civil engineering projects much focus is placed on creating flexible constructions. However the way of tendering projects creates specific characteristics on including and valuing flexibility.

- The output specifications have to be predetermined and fixed for all parties. This needs to be done to both be able to compare the different bids and to be able to draw up contracts without any room for legal unclarities. The need of contracts decreases the possibility to react on changing boundary conditions.
- Market parties can not exploit the upward earning potential of changing the changing boundary conditions, since the payment is based on the predetermined and fixed output requirements. Therefore market parties have to focus on options within the given fixed output requirements.
- Market parties have no opportunities to include own recognized and developed design options, since the output specifications are fixed.
- The tendering of civil engineering projects is largely influenced by “budget-thinking”. Because the budget is only reserved at the start of the project this creates one point in the project when decisions can be made. Each consequent decision in later phases of the project, requires a new process of budget reservation at government level. Because this is a elaborate process this reduces the possibility of reacting on changing boundary conditions.
- The government generally starts the tendering of a new construction when a public need is apparent and demand is to a large extent known. This reduces the possibilities to include flexibility in the design of the constructions. Only in some projects of the government, the development of a project is initiated to anticipate future demands. In these projects flexibility can play a large role.

9.2.3. Difficulties of the valuation of flexibility in civil engineering projects

Although including flexibility in the design has proved added value, including the valuation of flexibility in the project valuation faces some difficulties. The difficulties generally arise from the tender process and the characteristics of flexibility in civil engineering projects.

- The “budget thinking” of the government reduces the possible decision points in the project. The decision points during the project’s course enable the reaction on changing boundary conditions. The budget however is fixed from the start of the project and only includes initial investments

- The public tender process requires fixed output specifications. Because these uncertain design parameters are set fixed, the possibility to react on unexpected changes in these parameters is not possible.
- In most public tendering the project is developed once the public need is known. Next to this experience with such projects limits the value of flexibility.
- The projects initiate by the public parties, the primary function is both clearly stated and relatively stable. Therefore changes in boundary conditions will be small and reduces possibilities of flexibility.
- The party responsible for including the option in the design is generally not the same party as the one profiting from the execution of the option. Although market parties stay an active partner in the exploitation phase in DBFM-contracts, the large opportunities lie in exploitation of the construction itself. In maintenance the options stay of smaller size.
- The societal benefits are hard to include in a valuation than commercial cash flows.

9.2.4. Criteria for application of valuation of flexibility

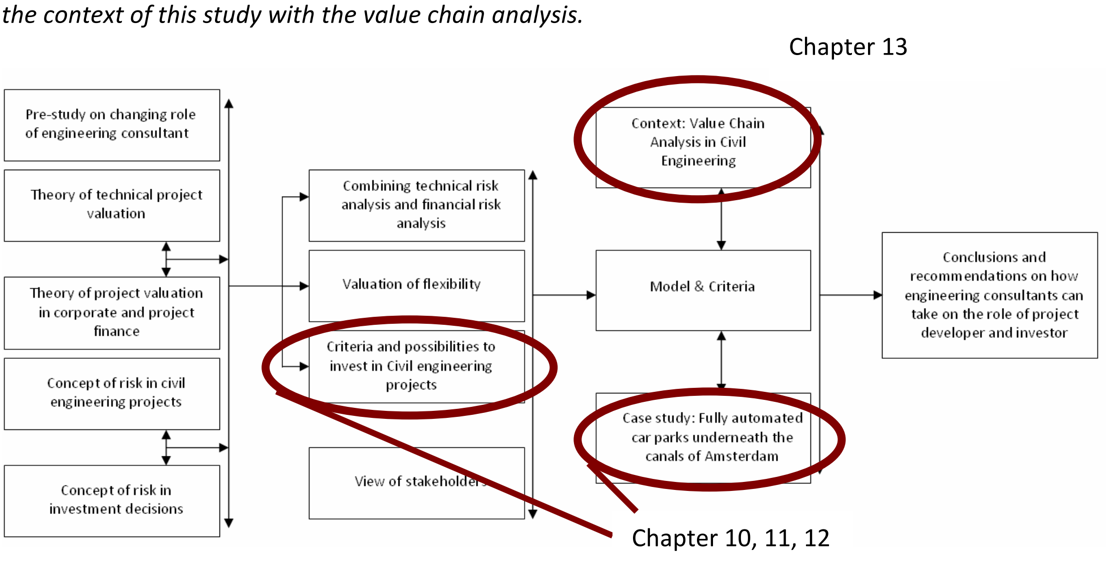
In order to be able to implement the valuation of flexibility in the project valuation some criteria can be identified. The current structure needs to be adapted in order for succesfull application of real option analysis.

- Budget should be available easily, in order to be able to react on changing boundary conditions or execute options. With a more freely available budget more decision points in the project can be introduced.
- Output specifications should be stated so that not only the output requirements are specified but also that market parties can profit from upward earning potential in the exploitation.
- Options that are identified from upfront and are interesting to the ministry of finance lie in the exploitation. To optimally benefit from option-thinking, the responsibilities of construction and exploitation should lie with the same party. For most public tendered construction this is not the case. However for more market oriented construction this can be interesting.
- Execution of options and alternative usages should have a large enough function and a large enough value in comparison to the primary function of the construction. If this is not the case the value of the flexibility is too low or too hard to identify.

PART IV: CASE STUDY FULLY AUTOMATED CAR PARKS

The attractiveness of developing and investing in civil engineering projects depends on a large number of project specific inputs. The general model has to be adapted to the circumstances of the project. In this research the model zooms in on developing and investing in a fully automated car park underneath the canal Boerenwetering in Amsterdam. The application of this case study required the model to be adjusted for car park specific input variables.

In chapter 10 an introduction to the project is given. This chapter gives an overview of the assumptions and it sources used to model the project's course as well. The chapter concludes with criteria and opportunities for developing and investing in car parks. In chapter 11 a summary of the model output is given. In chapter 12 the effects and results of the valuation of flexibility are given. Chapter 13 gives the context of this study with the value chain analysis.



10. FULLY AUTOMATED CAR PARK

10.1 Introduction

The case study in this thesis discusses the feasibility study of the development and investment in fully automated car parks underneath the canals in Amsterdam. In this chapter the characteristics, assumptions and context of the project are described. In the next chapter the base results from the model are presented. In chapter 12 the results of the valuation of flexibility are presented.
In section 10.2 a brief description of the history and current situation regarding car parks underneath the canals in Amsterdam is given. Section 10.3 covers the characteristics and assumptions of the fully automated car park at the location of the Boerenwetering. The location, dimensions and exploitation are briefly discussed. The model input towards the cost estimation, time planning and risk analysis si described in the second part of this section. The market side of the car park is presented in section 10.4. This discusses the need for parking spaces in this part of Amsterdam and the determination of the expected occupation rate. This chapter is concluded with a section on the possibilities and assumptions of alternative use of the construction. In this case study the possibilities of exploitation as self storage space is discussed.

10.2. History and current situation of car parks underneath the canals

10.2.1 History of car parks underneath the canals

Parking pressure in Amsterdam is very high. Due to the high number of people living and working on a relatively small surface and restricted amount of free space, finding a parking space in downtown Amsterdam can be troublesome. Hourly parking fares have risen to high levels and long waiting lists for obtaining licenses are common practice in Amsterdam. The current market situation for parking has resulted in high prices that are paid to buy parking spaces. Due to the high revenues which can be made per parking space, new possibilities for creating parking spaces have surfaced.
In the mid 1990s the city of Amsterdam started with the idea of creating car parks underneath the canals. Although commercial exploitation was not feasible in that current market situation, multiple locations were identified where car parks could be created underneath the canals. By creating parking spaces under ground level, the view of streets without any cars parked would improve. In the late 1990s the political atmosphere changed which postponed the development of these car parks underneath the canals.
Over the last couple of years, parking pressure increased even more. The average ownership of cars per household in Amsterdam grew in combination with an increase of population in the Dutch capital. Next to increased parking pressure in the beginning of the 21st century, fully automated car parks were developed and constructed. The main advantage of fully automated car parks is that a larger number of cars can be parked on the same area. This way more car parks could be realized on the same area underneath the canals. This improved the expected profitability just enough that car parks underneath the canals became feasible.

Last year the city of Amsterdam developed a new policy towards the accessibility of and parking possibilities in the city center. Old and environmental unfriendly cars would not be permitted to have access to the city inside the highway rink. Secondly the number of cars parked on ground level had to be reduced. The start of the developing car parks underneath the canals in Amsterdam was initiated. The first three locations were identified around the city part “De Pijp” in Oud-Zuid. The first car park underneath the Boerenwetering was tendered. The second location underneath the Singel on the north side of De Pijp will be tendered in the near future.

10.2.2. Current situation of car parks underneath the canals

The city of Amsterdam is not the only party developing plans for underground space projects. Strukton published its plans to develop an entire city underneath Amsterdam in January 2008. In this plan called Amfora a whole network of constructions would be created under the canals which would house cinemas, shops, car parks etc. This way extra facilities and space would be created without affecting and even improving the reachability of the city of Amsterdam.
The tender under the Boerenwetering was given to Parkeercombinatie Holland (PCH) in fall 2007 in the form of a preliminary agreement. PCH is a subsidiary company of Volker Wessels. PCH and the city of Amsterdam are now doing studies on the feasibility of the car park. If realization will begin the project is expected to be finished in 2011.
Royal Haskoning is interested in developing the car park together with Parkeerfonds Amsterdam. The case study for this research is to investigate the attractiveness to take active part in the risk of the possible development of the car park.

10.3. Fully automated car park Boerenwetering

10.3.1. Location

The location of the car park underneath the Boerenwetering is located in the city center of Amsterdam, just outside the Singel. The car park is located in city part Oud-Zuid. The car park is mainly intended for the resident at the east side of the car park, living in the Oude Pijp. The entrance of the car park will be located at the east quay of the Boerenwetering, the Ruysdaelkade (see Figure 37 right panel).

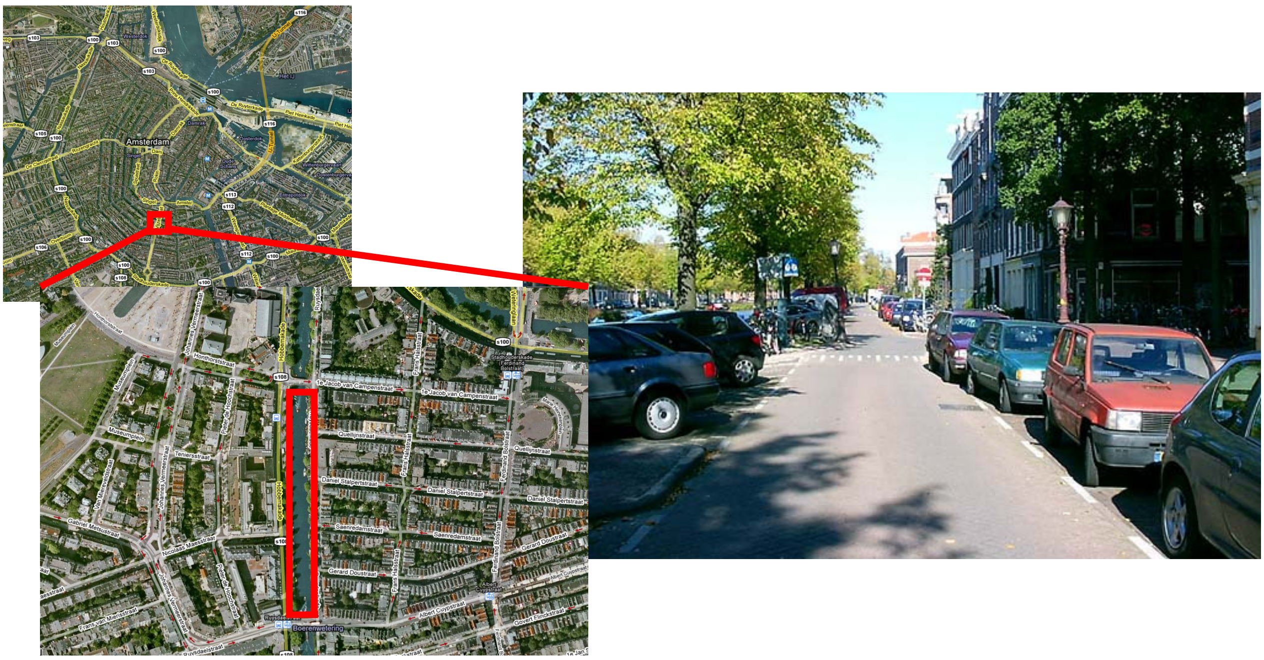


Figure 37 Location of the car park Boerenwetering in Amsterdam (left part) and the street scene of the Ruysdaelkade at the location of the car park facing north (right part; indicated with a yellow star)10.3. Boerenwetering car park

In the Oude Pijp the housing consists of a lot of small apartments, of which around 80% are rental apartments. From studies of the city of Amsterdam followed that the parking situation in the Oude Pijp is very tense (see appendix I)

10.3.2. Dimensions of car park

The design for the fully automated car park is shown in figure 38. In the initial design the car park consists of three floors and 7 entrances at the Ruysdaelkade. The alternatives that is discussed in the case study as well, consists of 4 parking floors. In appendix VI is calculated that the number of entrances then needs to be extended to 9 entrances to keep the waiting time acceptable. In Figure 38 the cross section of the design is shown. In appendix III other design drawing are given of the car park. The car park has a total length of around 263 m and 13,6m wide. The outer walls are 0,8m and the roof and the floor consist of 1m concrete.

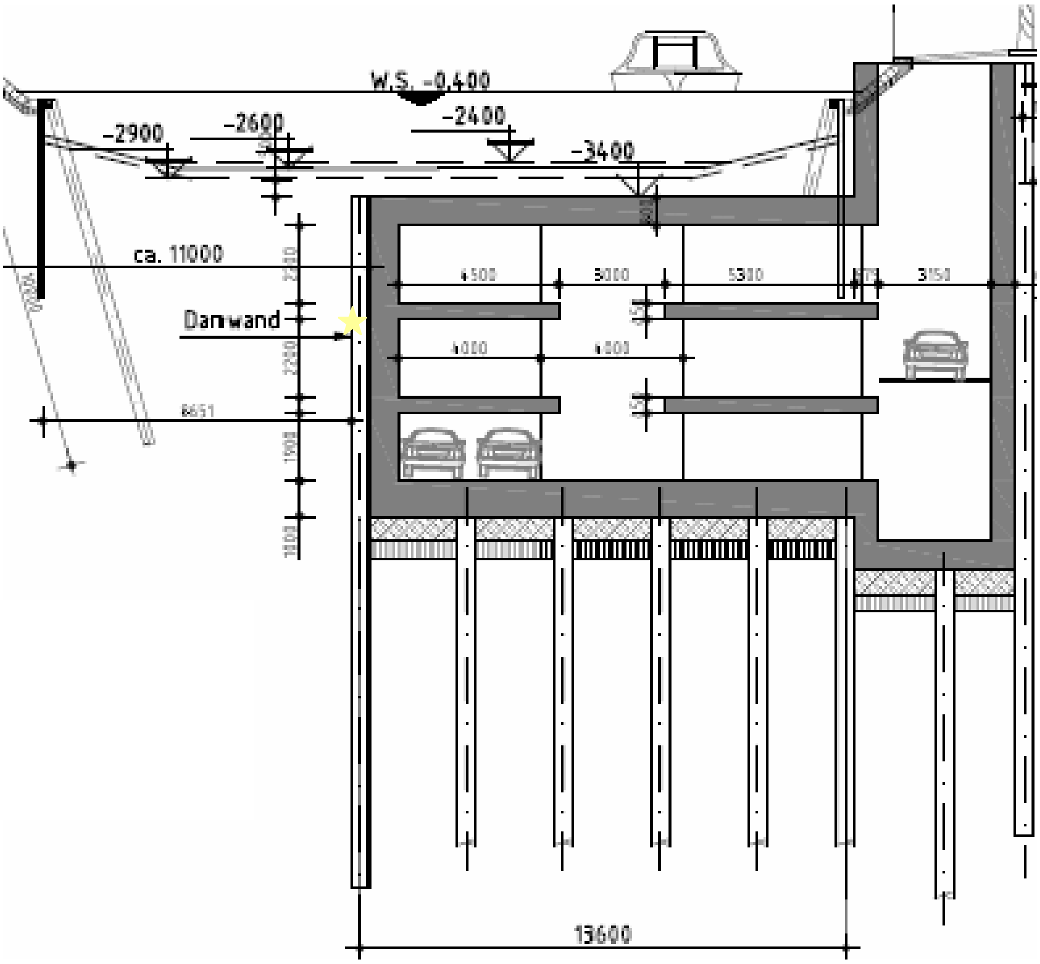


Figure 38 Cross section at the location of a shaft

On the three parking floor the cars will be parked in longitudinal direction in two rows next to each other. This option is chosen so that the width of the construction can be minimized and the cars do not have to be rotated after intake. This reduces the costs of the system and the loads on the system. In order to be able to reshuffle the parked cars by the system, some reservations of free spaces need to be made. In the case study is assumed that per 16 spaces, 1 parking space is needed for the system to function or other installations.

The sheet piling (0,169 ton/m) is permanent and runs into the clay layer at 25m – NAP (see appendix III for graph of soil conditions). The construction in the design with the three parking floors has a concrete floor at the top of the sand layer at 12m-NAP. Crossing this layer with the construction will increase the geotechnical risk and costs during construction significantly due to expected ground water flows. The foundation is planned in the second sand layer at 18m-NAP. Since the constructions in Amsterdam have poor foundations, vibrations and hindrance from construction noise should be reduced. Therefore the sheet piling and the foundation piling need to be driven in without noise and as little vibration as possible. For the piling fundex piles are assumed in order to reduce the hindrance to the surroundings.

10.3.3. Exploitation

The car park will have a length of 263 m and a width of 13,6 m. On the three floors of the car park around 460 parking spaces can be realized. In the case of a 4 storey car park around 610 parking spaces can be created. The parking system costs approximately €15.000 per space. The total number of parking spaces that can possibly be realized on the surface area is reduced due to two reasons.

- Per entrance the mechanical parking system requires no limitation by the construction. Therefore per entrance 6 parking spaces can not be realized in order to ensure the mobility of the parking system.
- Per 16 parking spaces 1 parking space is kept free for mobility of and reorganization by the parking system. To minimize the time the customers have to wait for their car the system reorganizes the cars parked. To be able to reshuffle and put cars away quickly in rush hour, it is assumed that the parking system requires 1 free parking space per 16 parking spaces.

The 460 parking spaces are divided into 75% short term parking spaces and 25% licensed parking spaces. The fare for short term parking in this area of the city is 3,80 €/hour. The average occupation rate for the short term parking spaces is 35%. Because the car park is fully automated the car park can be operational 24h per day, 7 days per week.
For the different sorts of licenses and their costs see Table 5. More licenses than spaces can be sold if double use is taken into account. This can be seen in the last column of the table. For an extended description of the derivation of these numbers see section 10.3 and 10.4. In appendix I and II the integral calculation is given.

	Parking times	License cost	Distribution over licensed spaces
Full License	24 h per day, 7 days per week	€ 2500 per year	60 %
Office License	8h – 18h on work days	€ 1800 per year	40 %
Resident license (nights)	18h – 8h on all nights	€ 1200 per year	40%

Table 5 Licenses and prices

10.3.4. Cost estimation and time planning

In the model the design, cost estimation and time planning are modeled using a probabilistic approach. In section 11.2 the results from the simulations are presented. For the 3 storey car park the total construction costs add up to € 33,7 Mio. Construction will take 157 weeks. For the distribution of these parameters see section 11.2. These results are obtained base on the assumptions for the cost estimation and time planning.
In the assumption worksheet of the model the design is translated into the design parameters. Uncertainties are taken into account by using a probability distribution for the uncertainty parameters. Generally normal distributions for these values are assumed. The uncertainty in unit prices is assumed to have a triangular distribution. The most probable, lowest possible and highest possible values for the unit prices are determined. As is usual in risk management, the lowest possible and highest possible values are set to be the 5% and 95% underceeding levels. The same approach as for the unit prices is applied to the time planning.

The distributions that are assumed for the design parameters are listed in appendix V. In appendix III the input for the cost estimation and time planning is listed. The unit prices and planning depend on the construction phase. In appendix III the Gant-chart of the construction is shown. The construction is made in situ using drilled in sheet piling. This is done to reduce the vibrations and noise for the neighborhood. The pouring of the concrete construction is done in 13 phases of 20m. The pouring of the concrete floor, outer walls, inner walls and roof each take one week time. This results in a construction time of 1 month for each section of 20m. This construction in phases allows reuse of casting and reduces logistic difficulties. After the construction is completed the construction runs on two different parts. The outside of the construction is finished and the quay is restored. And inside the technical installations are installed. One month later the installation of the fully automated car parks is started.

Due to the way of constructing it is assumed that one quarter before the car park is finished half of the parking spaces are ready for use. At completion this percentage has risen to 75% and 1 quarter after finishing all parking spaces will be possibly used. From data from the supplier of the parking systems follows that the availability rate of the system in the first year of exploitation will be 90% of the time. After one year this will be at a maximum of 98% of the time.

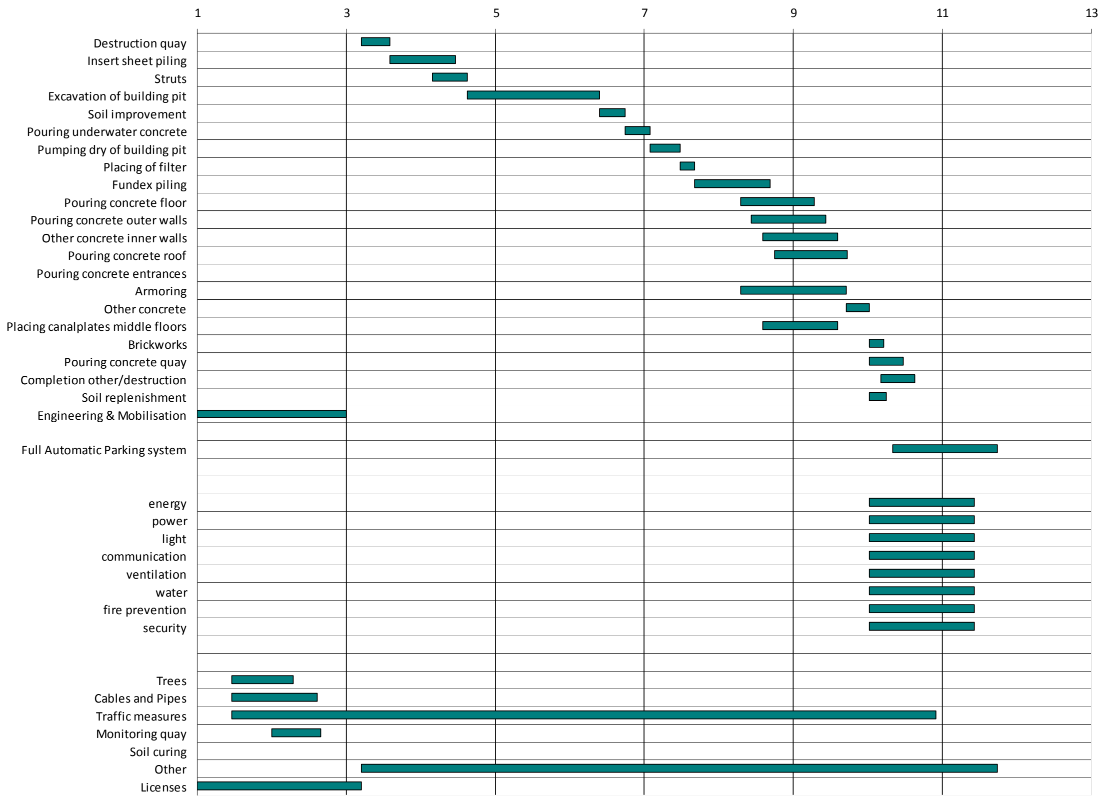


Figure 39 Gant chart of construction (in quarters and based on most probable durations)

The life cycle costs are also influenced by the costs of operation and maintenance, and replacement. The costs for the replacement of the component at the end of its life and maintenance are combined in the ongoing CAPEX. This yearly cost is divided into the ongoing CAPEX for the construction (lifetime 40 years; 2,5% per year) and the installations (lifetime 15 years; 6,7% per year). The operational expenditures are divided into those for the parking system and the installations. In the ongoing OPEX also the maintenance of the parking system is included. This value (7% of investment costs per year) is supplied by the parking system supplier. In appendix V the values for these parameters are listed.

10.3.5. Risk Analysis

The traditional cost estimation uses surcharges on the construction cost to take further design, preparations and object and project unforeseen into account. These percentages are also applied in this financial model. These percentages are extended with a short risk analysis, identifying the most

important risk. This risk analysis is performed based on standard Risman classification. Both the classification and the ten largest risks that are identified in this phase are given in appendix IV.
In the risk analysis a probability of occurrence is allocated, a financial consequence and a time consequence. The time consequence is quantified by multiplying the delay caused by the costs of keeping the construction site open for one day, which is determined to be €10.000 per day. Secondly the time delay is included in the time planning. In the model the expected value is subtracted from the initial object and project unforeseen. The expected value of these two risk reserves and the expected costs from the risk analysis therefore stay constant in comparison to the initial cost estimation. However the spread due to uncertainty in a model simulation can differ. The percentage is modeled to have a spread. The risks are modeled by special event.

From the total list in Appendix IV the risks with the largest consequences can be read. The first four in the list are technical risks and the 5th is an operational risk related to the technical system:

	Risk	Probability	Consequence
1.	Mistakes in design due to wrong assumptions	25 % - 50 %	4 month delay + €500.000 - 1.000.000
2.	Construction site can not be reached by city traffic or events	25 % - 50 %	1 month delay + €250.000-500.000
3.	Vibrations and other construction activities cause damage to buildings near construction site	10 % - 25 %	4 month delay €250.000 - 500.000
4.	Affected groundwater table causes damage to building near construction site (wooden piling)	10 % - 25 %	4 month delay €250.000 - 500.000
5.	People are reluctant to use the automatic system	10 % - 25 %	no delay >1.000.000

Table 6 Overview of 5 largest events from risk analysis with their assumed probability and consequence

10.4 Parking space supply and demand

10.4.1. Market research for parking spaces

The market situation for parking spaces has a large effect on the feasibility of developing a fully automated car park. The market side consists of three factors in the near region surrounding the car park influencing the exploitation of the car park.

- Parking space supply
- Parking space demand
- Parking policy

The insight into the parking situation is needed to determine the occupation rate which is feasible for the fully automated car park underneath the Boerenwetering. The parking policy is left outside the scope of this study because this is highly volatile and requires more study.

10.4.2. Influence area of car park Boerenwetering

In determining the need for parking spaces the parking balance should be determined. In the parking balance the supply and demand of parking spaces are evaluated given the current parking policy. The need for the new development of parking spaces then follows from the parking (Im)balance in the influence area of the new car park. The demand is calculated using the steps described by the CROW ([72]). In this report the parking policy is assumed to stay constant from the situation as it is now. The city of Amsterdam has the policy to reduce the number of cars present in the city center and reduce the number of parked cars in order to improve the view on the street. The parking spaces that will be constructed underneath the canals will replace parking spaces on ground level.

The influence area of a car park is mainly determined by the distance visitors or citizens are willing to walk from the car park to their destination. The distance they are willing to walk depends on the function they are visiting. In order to determine the supply and demand therefore the area is set on the acceptable walking distances. In [72] a list is given for acceptable walking distances. These distances depend on:

- Attractiveness/safety of walking route
- Policy and pricing of parking
- Competitiveness of alternatives

The factors can cause deviations in the numbers if the location around the Boerenwetering is considered. Residents in this part of Amsterdam are expected to be willing to walk 200m to their car due to the current problematic parking situation. Due to this parking situation and the attractiveness of the public transport, the acceptable distances for working and shopping are reduced. In Table 7 the acceptable walking distances for the car park Boerenwetering are given. The main functions in this area of the city are restricted to living, shopping and working. Living is the most important function. In Figure 40 the influence area's of the car parks is plotted. In these maps it is assumed that only entrances will be realized on the east quay of the car park.

Function	Acceptable Walking distance
Living	200 m
Shopping, recreation	500 m
Working	500 m

Table 7 Acceptable walking distances for available functions near car park Boerenwetering ([72], 2003)

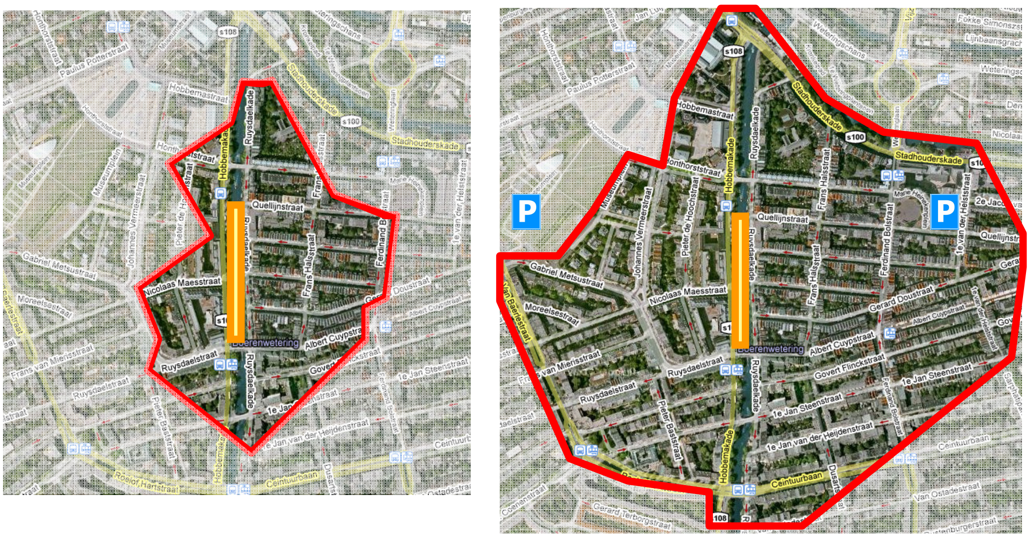


Figure 40 200m (left panel) and 500m (right panel) influence area's of the Boerenwetering car park

The parking supply in the region now can be determined. In appendix I the derivation of the parking supply is described more extensively. The total supply in the 200m influence area adds up to 1120 parking spaces. In the 500 m influence area it adds up to 2900 parking spaces. In these 2900 parking spaces the 600 parking spaces of car park Museumplein and the 256 spaces of the car park Heinekenplein are included.

10.4.3. Parking demand around the Boerenwetering

For the parking balance the demand for each function inside the influence area needs to be calculated. This calculation is done primarily using the guidelines and experience numbers described by CROW (2003, [72]). The determination of the demand for parking spaces is split up over the functions living, shopping, working and recreation. For the function living the number of households is inventoried and multiplied by the average number of cars owned per household. For the other functions a similar approach is taken. The number of facilities is inventoried and multiplied by the average number of cars needed per facility. The derivation of the parking space demand is described in detail in appendix I.

If the demand per function is known, double use over the week should be taken into account. Parking spaces of residents can be used for the function working of shopping during the day. The overall parking demand can be calculated by multiplying the demand per function by the presence percentages given by the CROW. For the 200 m region the demand and supply for parking spaces is listed in Table 8. On top of these numbers, parking spaces will be required to facilitate shopping in a range between 200m and 500m from the car park. This is discussed in appendix I.

Function	Workday Morning	Workday Afternoon	Workday Night	Shopping evening	Saturday afternoon	Saturday Night	Sunday afternoon
Parking demand (#)	1370	1600	1520	1600	1180	1050	940
Parking supply (#)	1120	1120	1120	1120	1120	1120	1120

Table 8 Required parking spaces for a 200m influence area around car park Boerenwetering

If the parking spaces in the car park replace the parking spaces on ground level, the demand for the car park is high enough. For large parts of the week the demand is also high enough if the parking spaces in the car park are added to the number of car parks at ground level. If the share of demand for parking spaces for shopping and working in an area of 200m-500m is included, the imbalance in the parking situation will be even higher.

10.4.4. Determination occupation rates

An important parameter in the feasibility study of a car park is the occupation rate. In the model the input parameter occupation rate is an average value of the occupation rates over a long period (> year). In the model the average occupation rate over a week is taken as average long term occupation rate. Seasonality in the occupation rate is neglected. In the car park two different groups of users are identified.

- Licensed parkers, generally for functions working and living
- Short term parking, for the functions of shopping and pubs & restaurants.

Short term parking is more profitable. However the cash flows have a higher risk due to larger volatility. Short term parking mainly takes place during the day. Licensed parking is less profitable and cash flows are less volatile. Licensed parking is especially interesting for residents and people working in the area. Since the demand for short term parking exceeds the supply around the Boerenwetering and the city of Amsterdam wants to reduce the number of parking spaces on ground level, a high number of short term parking is attractive in order to maximize the profit. In feasibility studies by the city of Amsterdam (2004, [21]) a ratio for licensed parking spaces to short term parking spaces of 20% : 80% is given. Because the high demand for living and working, in this study a ratio of 25%:75% is assumed.

In this study the ratio is set to be fixed. During exploitation an optimization could be done to adjust the number of licensed parking spaces to the demand at a certain time. In hours where licensed parking demand is high, a larger number of license places could be reserved. When short term parking demand is high, the number of licensed spaces can be reduced again.

For the determination of the occupation rate for short term parking, figures from 6 car parks in city centers of Dutch cities are used. These numbers and the derivation of the occupation rate are described in appendix II. From this figures follows that the occupation rate is especially determined by the length of the peak and the occupation rate for short term parking at night. The occupation rate at daytime is (almost) 100%. Focusing on the increase of the number of cars parked at night and evening can improve revenues. From the study follows that an occupation rate of 35 % is realistic. In the worst case this could fall back to 20%.
To optimally use the 116 parking spaces that are reserved for licensed parking, double use of these parking spaces should be considered. Offering different licenses can increase revenues by double selling of parking spaces. Based on the presence percentages of the CROW the distribution of licenses can be determined to optimally fit for presence and parking demand. This way the licensed places have an occupation rate close to 100%. The determination of the distribution of different licenses is described in appendix II. Basic assumption for this is that the amounts of licenses should be based on the demand in the region for licenses. In Table 9 the different licenses are listed and the distribution over the licensed parking spaces. The prices in the table are according to the market and similar to the prices Q-park asks for their licenses.

	Parking times	License cost	Distribution over licensed spaces
Full License	24 h per day, 7 days per week	€ 2500 per year	60 %
Office License	8h – 18h on work days	€ 1800 per year	40 %
Resident license (nights)	18h – 8h on all nights	€ 1200 per year	40%

Table 9 Licenses and prices

The expected overall occupation rate over a one week timeframe is then little over 51%.

10.5 Alternative ways of exploitation

With developing car parks a lot of risks are involved towards the exploitation of fully automated car parks. In the Netherlands not many successful examples have been realized until present. The couple of existing fully automated car parks have shown problems and received negative media coverage. Realizing and exploitation of a conventional car park is not feasible to the lack of space and the high investment costs per parking space. Due to the uncertainty towards the flawless functioning of the mechanical system and the effect of the psychological barrier to use a mechanical system, alternative ways of exploitation are considered. In the case the car park turns out to be not exploitationable, considering switching to alternative exploitation is advisable.

Due to the lack of space in the center of the city of Amsterdam, underground space can be used for multiple functions. In the study of Amfora the underground spaces are mainly used for leisure functions, such as sporting facilities, gyms etc. Also possibilities have been raised to house a supermarket in the underground construction. However the relative low ceilings on each floor make this exploitation difficult.
The floors with low ceilings are not problematic for the exploitation as self storage spaces. The construction could be easily adjusted to fit in a self storage business. In these self storage spaces customers can rent a sort of parking garages in which they can store stuff. Customers can be local residents stowing away old stuff of little businesses who need an extra temporary storehouse.

For the alternative exploitation some assumptions are made in order to valuate the option of changing exploitation.

$$p_{m^3\ selfstorage} = 20\ €/m^3\ /month$$

$$h_{other\ floors} = 2{,}2\ m$$

$$p_{m^2\ selfstorage} = 44\ €/m^2\ /month$$

$$occupation\ \ rate_{average} = 85\%$$

$$occupation\ \ rate_{\ worst\ case;\ 95\%} = 65\%$$

$$p_{m^2\ selfstorage} = 450\ €/m^2$$

$$p_{m^2\ selfstorage\ worst\ case;95\%} = 350\ €/m^2$$

$$\sigma = 50€/m^2$$

The switching costs are estimated to have a net present value of 1 Mio€. It is assumed that the fully automated parking system can be sold for 80% of the initial CAPEX after one year of exploitation.

In this chapter…

In this chapter the characteristics, assumptions and context of the project are described. The idea of car parks underneath the canals in Amsterdam was initiated in the 1990s. Because of the technical development of fully automated car parks, the high parking fares (3,80€/hour) and the large demand for parking spaces in Amsterdam, the development of car parks underneath the canals became feasible. The car park consists of 3 storeys having approximately 460 parking spaces (€15.000 costs of system per fully automated parking space). Of these parking spaces 75% is for short term parking and 25% is for licensed parking spaces. The construction has a length of 263 m and a width of 13,6m.The construction has a height of 9m

The cost estimation and planning are done by a probabilistic cost estimation and planning. With the model the uncertainties in the design parameters are included in the valuation. For the unit prices and the construction times of each activity a probability distribution was estimate by determining the most probable value, the least likely and most likely value. Next to this a short risk analysis of the car park was executed to get insight into the largest risks.

Important aspect in developing a car park is the market side of the car park. The parking demand and supply is inventoried using the guidelines by the CROW. From this study can be seen that the demand for parking spaces is much larger than the supply. The occupation rate follows from previous studies to be 35%. For the licensed spaces three sorts of licenses (full license, night license and office license) and double use of parking spaces is taken into account in the calculation. The expected revenues can be determined with these values

If the exploitation as a car park turns out to be unsuccessful, the exploitation can be changed. The car park can also be exploited as a self storage business. These assumptions can be used in the real option valuation.

11. MODEL OUTPUT AND ANALYSIS

11.1 Introduction

The results presented in this and the next chapter is based on the input of the case of the fully automated car parks underneath the canals in Amsterdam. The financial model used in this study is a probabilistic model. In the model both operational and commercial parameters are combined to obtain a integrated project valuation. The technical and operational input is based on the technical design. The input for the financial side is based on market studies and general market figures. In this chapter the main results of the case study are presented. The results are based on three simulation-cases:

- Base case with 3 parking floors (appendix X)
- Case with 4 parking floors (appendix XI)
- Case with separate operational, financial and market risk

The results described in this chapter are the results of the above mentioned simulations. The results per simulation can be found in appendix X and XI. In this chapter the following results are presented:

- Results of base case with 3 parking floors (section 11.2)
- Sensitivity analysis of base case (section 11.3)
- Results of case with 4 parking floors (section 11.4)
- Effects of the financing structure (section 11.5)
- Relation between technical, financial and market risk (section 11.6)

The quantitative model input of the base case is listed in appendix V. The derivation of this project input and the assumptions used are described in Appendix I to VII. The project input for planning, cost estimations and for the general car parks assumptions were discussed with experts. The actual project input is described in

- Appendix I (parking space supply and demand)
- Appendix II (determination occupation rates)
- Appendix III (Case study input planning and cost estimation)
- Appendix IV (Brief risk analysis)
- Appendix V (Case study input)
- Appendix VI (Calibration by hand calculation of 3 and 4 storey car park)
- Appendix VII (Sensitivity analysis)

11.2 Results base case (3 parking floors)

The results of the base case give an insight into the financial feasibility and attractiveness to develop and invest in car parks. The input of the base case is based on the current design and current and expected market conditions. In this section the main results of the base case are presented.
The expected outcome of the project can be calculated by the model by inputting the mean values for all parameters. All model input parameters are listed in appendix III and V. The base case has some important assumption and initial values:

- Project life = 30 years
- Number of storeys = 3
- Number of parking spaces = 464
- No variation of interest rate and inflation
- No increase or decrease in hourly parking fare by city of Amsterdam (€3,80/h)
- Other technical and financial risks included
- Mean construction costs = € 33,7 Mio (result simulation)
- Financing reservation = € 41,0 Mio (result simulation)

The discount factor is an important parameter in judging the attractiveness of an investment. For all investments the Weighted Average Cost of Capital (WACC) determines the required return on the equity invested in the project. If a project is discounted with the business specific WACC and has a Net Present Value (NPV) of 0, the equity yields a yearly return equal to the WACC. The WACC is used as a threshold for the lowest percentage an investment should yield in order to be attractive. This WACC demanded by the equity investor is linked to the risk the investor is exposed to. From practical numbers follows that for conventional car parks a market return of 7% is common. Since the risk of fully automated car parks is higher than of conventional car parks a WACC of 8,5% is used. This value is comparable to the WACC in similar industries and about 1 – 1,5 % higher than large infrastructure projects. In Figure 15 the real average rate of return on different sorts of projects are given. It follows from this figure that the real rate of return is several hundreds of base points (whole percents) higher than the WACC.

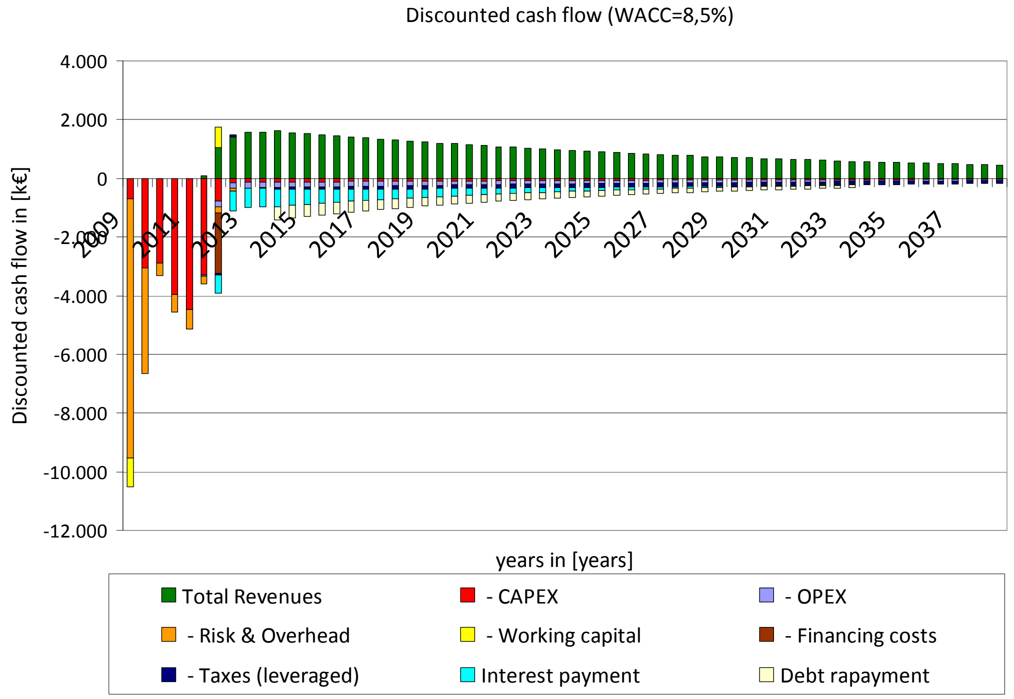


Figure 41 Expected discounted cash flows (WACC=8,5%) for a 3 storey car park

Based on the project input the expected cash flows over the project's life can be discounted using a WACC of 8,5%. In Figure 41 the contributions of the discounted cash flows with their origin are shown. Above the x-axis positive cash flows are shown and below the x-axis the negative cash flows. The ratio between the upfront investments and the net income in the exploitation can be clearly seen. In this figure the large risk reserve at the start of the project can be seen. Also the effect of the discount rate is clearly visible by the decreasing bars over the course of the project.

The most important figure for an equity investor is the net result which flows to equity after all expenses and costs are paid. The net cash flow to the equity holders can be determined by calculating the net results of the cash flows of Figure 41 and subtracting the debt financing. In Figure 42 the cumulative cash flow to equity is shown.

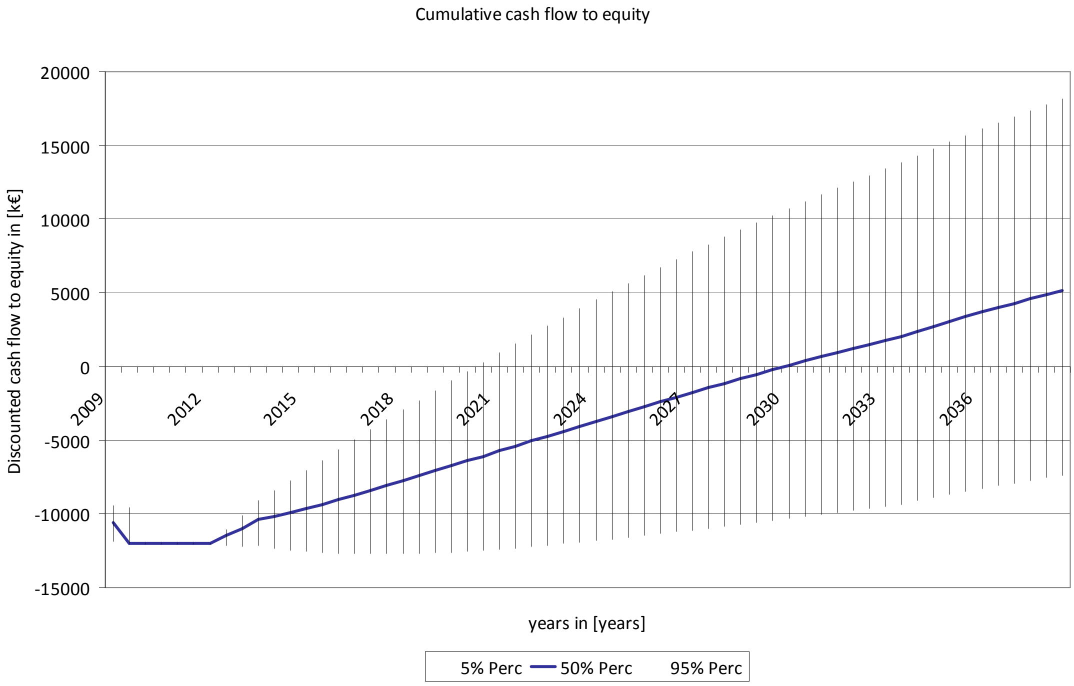


Figure 42 Cumulative cash flow to equity (WACC=8,5%) for a 3 storey car park

The blue line is the mean expected value of the cumulative cash flow to equity. With the vertical lines the 5% and 95% confidence intervals are shown. The 5% and 95% borders are retrieved from a Monte Carlo analysis. During the phase in which financing is needed first the equity is invested in the project. After all the equity is drawn, the project is financed using the debt portion. During this period no cash flow from or to equity occurs. The financing costs are postponed to the first period of the exploitation. In this period as well part (90%) of the working capital comes free again.

Expected return (Monte Carlo Analysis)

The project is modeled using a Monte Carlo analysis in order to take uncertainties in the project into account. The results give insight into the sensitivity of a project's profitability. For the calculation of the NPV a WACC of 8,5% is taken as threshold value for the minimum return of the investment (see section above).

In Figure 43 and Figure 44 the results from the simulation of the base case for the NPV and the Internal Rate of Return (IRR) are given. The NPV is the net present value of a profit which is made above the minimum percentage (WACC) the equity yields per year. The IRR is the return rate the equity yields, when the NPV over the entire project's life equals 0. From the figures can be seen that the project has a mean expected value of 5010 k€. The 95% confidence interval runs from -6700 k€ to +17400 k€. The probability that the NPV is negative is 24%. The IRR has an average value of 11,1 %.

The IRR has a probability of 95% to yield more than 5% per year on equity. In Figure 15 the returns for various projects in civil engineering are shown. In this graph it can be seen that the return on infrastructure the average yield is slightly higher.

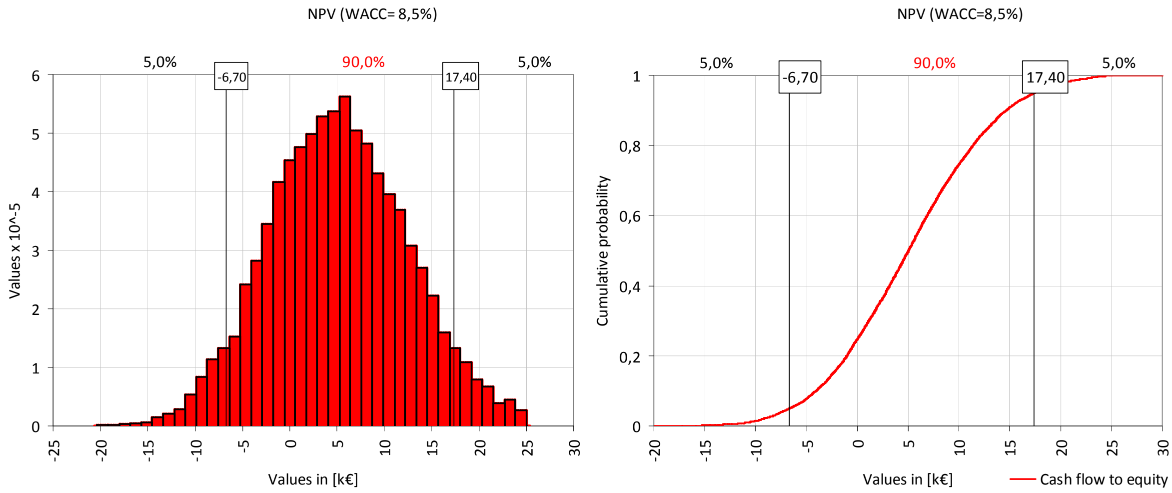


Figure 43 Distribution and cumulative probability of the NPV of a 3 storey car park

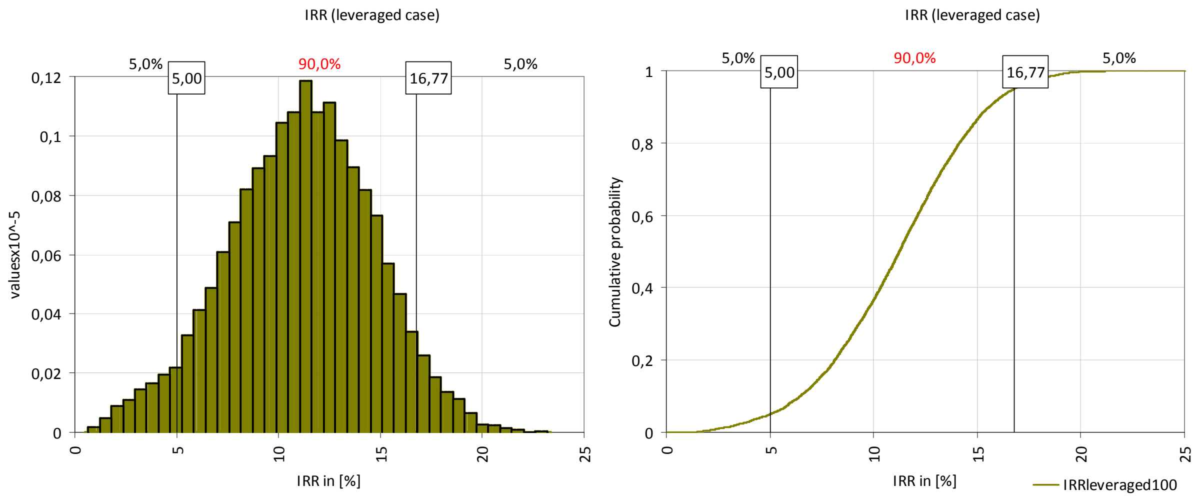


Figure 44 Distribution and cumulative probability of the IRR of a 3 storey car park

11.3 Sensitivity analysis

A sensitivity analysis is performed to get insight in the uncertainty of the input parameters that causes the largest effect on the output. Generally this is done by plotting the linear regression coefficients per parameter. The regression coefficient can be determined by plotting the distribution in results versus the distribution of the input parameter. If the regression is linear (formula is y=ax+b) then (a) is the linear regression coefficient. Since in this model not all input parameters have the same unit, the regression coefficients are normalized over the input parameters to facilitating direct comparison of each input parameter.

In this study the sensitivity analysis is done empirically by simulations of the model. In this section the results are presented from varying each parameter in the model separately. The regression coefficients are defined as the change in NPV per standard deviation of the input parameter. For each parameter the variations in NPV are plotted versus the random generated numbers of the input distribution. As an example the result of the regression analysis on concrete and steel unit prices is shown in Figure 45. Per simulation all other uncertainties in parameters are set to 0. In the output data, the linear regression line can be determined going through all data points with the least mean square on the Y-values. With the linear regression line the linear regression coefficient can be identified. In this analysis it is assumed that all parameters are independent. In appendix VII some of these dependencies that are neglected in this analysis are described.

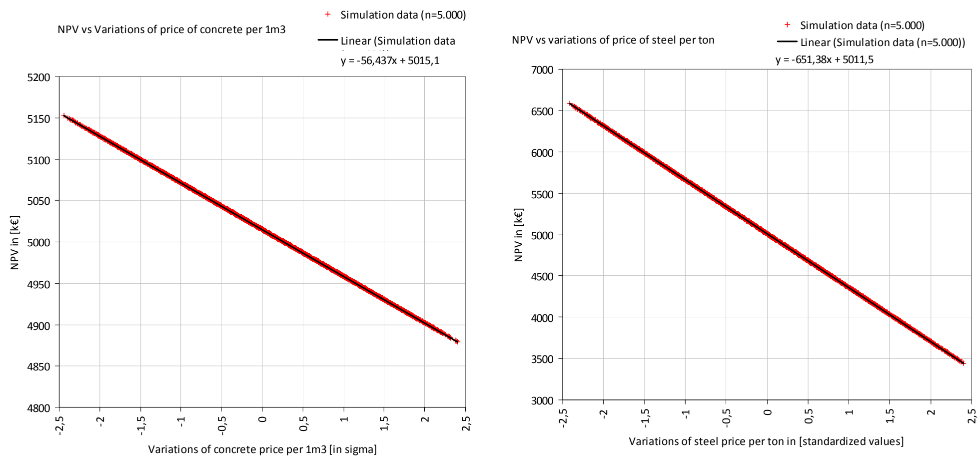


Figure 45. Regression analysis on concrete unit price and steel unit price

The regression coefficients are determined for all input parameters with a probability distribution. The regression coefficients are determined for the parameters amount, unit price and the risks in the risk analysis. In appendix VII all coefficients are presented. For the regression analysis the unit prices for concrete and steel parts of the construction, the material prices and handling prices were taken into account separately. This is done since material prices showed a large change over the last year. Concrete prices stayed relatively constant. However raw steel prices doubled in one year due to the link of the steel prices to the oil prices. For concrete a N(€ 100;€3) distribution per m^3 was assumed and for the steel prices a N(€1100;€ 150) was assumed. From the graphs above follows that the steel price has more impact on the outcome than variation in concrete prices, so that the steel price should be watched closely. Although oil prices have again dropped over the last months, the volatility in oil price can cause large fluctuations in the steel prices.

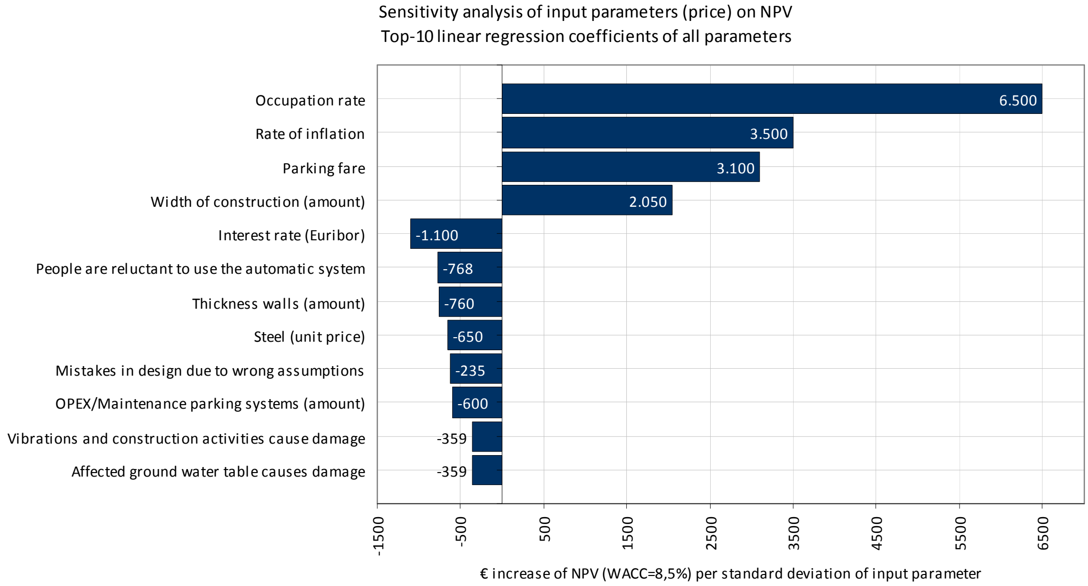


Figure 46 top-10 regression coefficients of input parameters on the NPV

The top-10 of impact of variation in input parameters on the outcome is shown in Figure 46. It can be seen from this figure that the most important uncertainties in the model, based on the distributions inputted, are the occupation rate, inflation, and parking fare. In the top 5 there are 4 financial and market oriented parameters, which indicates the large influence of market and financial risk in the development of a car park. Inspection of the data distributions over the parameters showed that for most parameters a linear dependence is a good approximation. This means in that the regression coefficient reduces by half if the standard deviation of the uncertainty is halved. This way the price of the measures for reducing risk can easily be compared with the standard deviation reducing effect the measures may have. Risk of interest changes are generally taken over by a bank. In Table 10 the parameters in the top-10 regression coefficients are listed with their assumed distribution.

A parameter that is not included in the regression analysis but has significant influence on the result is the number of parking spaces that needs to be kept free for the paring system to function. The system needs some places to remain free in order to be able to shuffle cars. The systems are designed to reshuffle the cars overnight, in order to minimize waiting times for the customers. For the system to work well, free spaces need to be included in the system. In the case it is assumed that each 16 parking spaces, 1 space is kept free (15/16 of the parking spaces can be used). Each additional parking spaces per 32 parking spaces that needs to be kept free, reduces the overall NPV with around 1 Mio€. Second additional note to the results is the parameter width of the construction on the 4th place. This parameter is included in the top listing because of the setup of the model. The number of possible parking spaces in the car park is determined on the surface area of the construction. An additional meter in width will increase the total surface and therefore the number of parking spaces. Because the distribution of the parameter number of parking spaces is not made discrete, the model assumes parking spaces can be constructed on that area. In reality this is however not possible. In future simulations it could be considered to fix the variation coefficient on 0.

Parameter	Distribution	Regression
Occupation rate	N(35%, 7,5%)	6.500
Rate of inflation	N(3%, 1%)	3.500
Parking fare	N(€3,80, €0,38)	3.100
Width of construction (amount)	N(13,6m; 0,68m)	2.050
Interest rate (Euribor)	N(4,5%,1%)	-1.100
People are reluctant to use the automatic system	B(1, 0,175)	-770
Thickness walls (amount)	N(0,8m; 0,08m)	-760
Steel (unit price)	N (€1100, €150)	-650
Mistakes in design due to wrong assumptions	B (1, 0,375)	-630
OPEX/Maintenance parking systems (amount)	N(7%, 1,4%)	-600
Vibrations and construction activities cause damage	B(1, 0,175)	-360
Affected ground water table causes damage	B(1, 0,175)	-360

Table 10 top-10 regression coefficients with assumed distribution

11.4 Variation of number of floors

The design decision on the number of floors of the car park has large impact on the construction and the cash flows. To decide which design will ensure the highest expected return, both cases have to be simulated. In appendix XI the effects on the project input of increasing the number of floors to 4 for the construction are discussed. Most parameters increase with the new construction dimensions. The most important changes for a car park with 4 floors that are inputted in the model are:

- One additional parking layer of 2,2 m height
- One additional concrete floor of 0,45m thickness

- Extra strutting required is 1,5 times base case
- Extra risk reserve of 2,4 Mio € for increased geotechnical risks
- Sheet piling increases 10% in weight per running m

The changed input parameters for the construction changes the general characteristics of the car park.

- Number of entrance increases to 9 entrances
- Total number of parking spaces = 610
- Total construction costs are €37,5 Mio
- Construction duration 197 weeks
- Financing reservation increases to 50 Mio €

The increased number of floors will both have an effect on the construction. If a larger amount of work needs to be done to construct the car park, a choice needs to be made how to plan the construction phase. Either the price of the work per unit goes up keeping the construction time constant. Or the price per unit can be kept constant, while increasing the duration of the construction works. In appendix VI is described which choice is made per parameter.

In Figure 47 and Figure 48 respectively the NPV and the IRR of a 3 and a 4 storey car park are shown. In these figures can be seen that although the 4 storey car park has a higher cumulative construction cost, the NPV over the life cycle and the IRR of the investment have higher expected values. The results for the simulation of the 4 storey car park are presented in appendix XI. From the Figure 47 and Figure 47 the numbers for the mean expected values in can be seen.

	3 storey car park	4 storey car park
Mean expected NPV	5.010 k€	7.500 k€
Mean expected IRR	11,1%	11,6%

Table 11 Comparison of mean expected values of a 3 and 4 storey car park

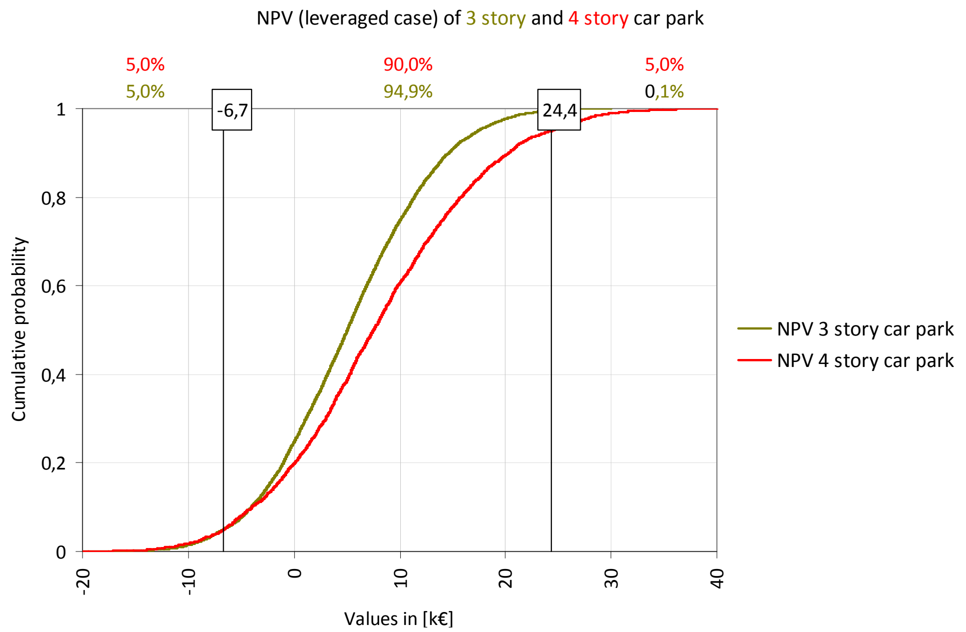


Figure 47 NPV of 3 and 4 storey car park (cumulative ascending probability)

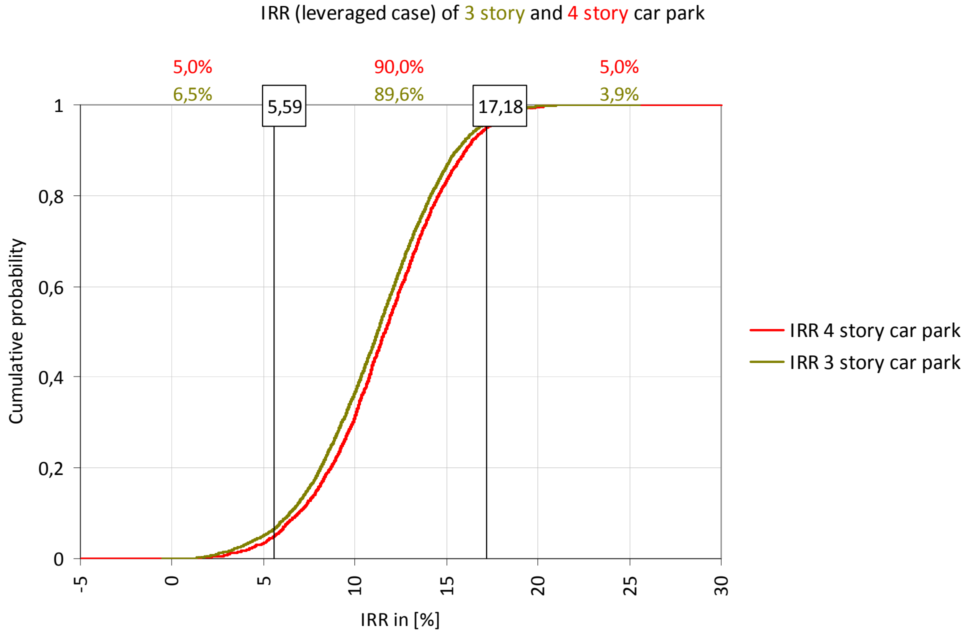


Figure 48 IRR of 3 and 4 storey car park (cumulative ascending probability)

The mean expected value of the NPV of the 4 storey car park is around 2,5 Mio € higher. The return on the equity over the project's life is expected to be about 0,5% higher. It can be concluded from these graphs that the increased number of parking spaces generate enough income to compensate the increase in construction costs. In this case important assumptions are that:

- The increased number of parking spaces in the 4 storey car park has no influence on the occupation rate of the overall car park in comparison to the 3 storey car park.
- Two additional entrances (9 in total) for the 4 storey car park are technically possible.

11.5 Influence of financing structure on NPV

The financing structure of a civil engineering project can have a large impact on the project's outcome. In this section the effect of some financing variations on the case study are described. The presentation of the results is intended to give an overview of the effects of financing structures on civil engineering projects. In this section several aspects are discussed when financing the development of the car parks of the case study:

- The effect of leveraging with debt on the NPV
- The effect of the leverage ratio on the IRR
- Risk of insolvency of financing
- Working capital reservations
- Value at the end of the lifetime

The two most important characteristics of project finance are the use of debt financing and the leverage ratio. For financing a project many financial components can be used to arrange the financing of a project. These components vary in risk profile, interest rate and repayment structure. To keep the study on financing a civil engineering project simple only the use of debt is taken into account. All external financial components used in financial engineering can be modeled by one portion of debt financing with an representative interest rate.

The effect of using debt financing in a project on the NPV is shown in Figure 49. The leverage case shows a higher NPV at all discount rates considered. This difference can be explained by the financial leverage and the Interest Tax Shield (ITS). The financial leverage is the profit made because in this case debt has a lower interest rate than the WACC. The costs of external money are therefore lower than the costs of equity. The second effect (ITS) is due to the fact that interest payments generate a tax advantage. Taxes are paid over the profit after the interest payments are subtracted from the Net operating income. This financial benefit reduces the amount of tax that has to be paid in comparison to the non leveraged case. Using debt financing increases the projects feasibility considerably.

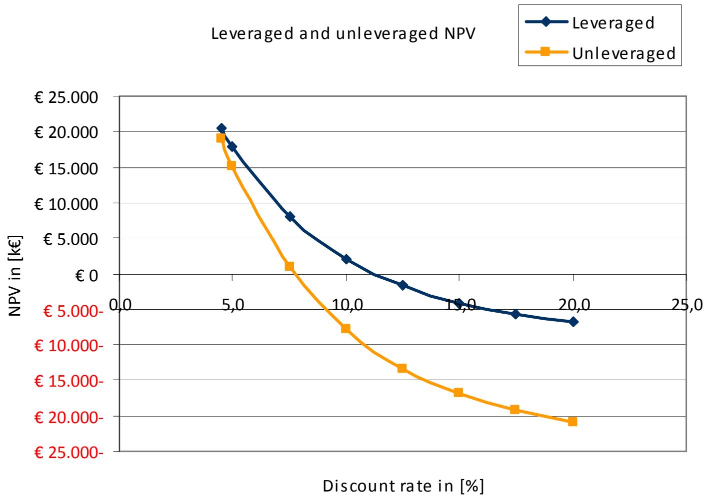


Figure 49 Effect of leveraging (30% equity) at various discount rates

Next to varying the discount rate, also the effect of the financial leverage can be quantified. By using less equity the IRR increases. However, by requiring less equity the risk for the debt financer will increase. These considerations are discussed in chapter 2. The allowable percentage of debt financing for the bank will be determined by the generated cash flows cover the debt service that should be paid. In other words, the risk embedded in the project's cash flows determines the maximum allowable financial leverage. For parking garages a ratio of 30% equity is considered normal. For large and stable infrastructure project this can be only 10% of equity. It can be seen in Figure 50 that a reduction of the debt portion by 5%, increases the IRR by almost 1%. This results in a NPV which is approximately 1 Mio € higher.

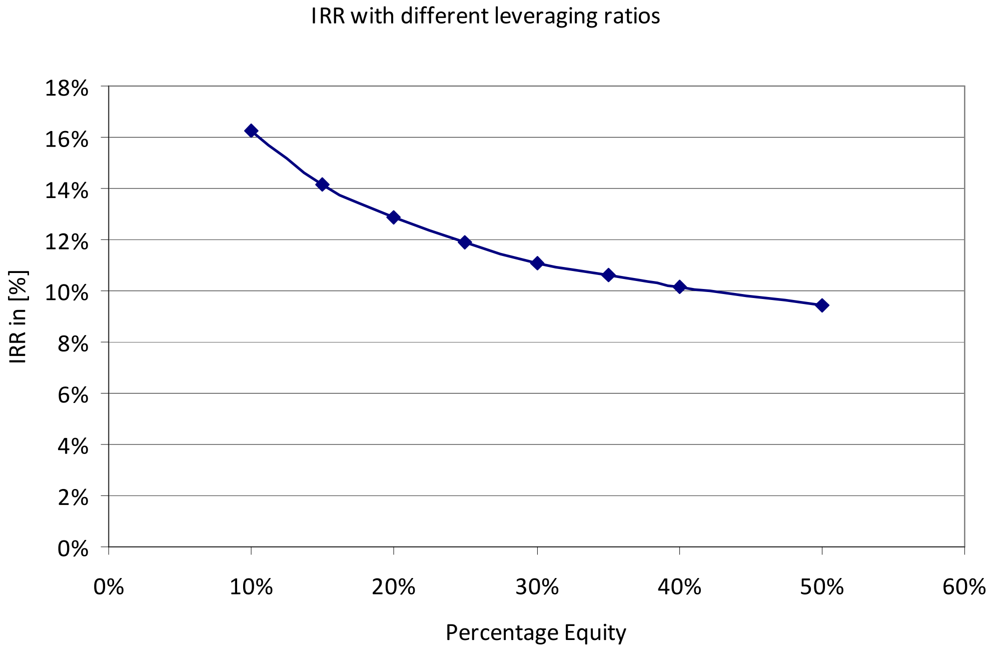


Figure 50 Effect of percentage equity on the IRR

It was concluded in chapter 6 that the two most important financial risks in project finance are the risk of insolvency for the financing and the risk of insolvency for the interest repayment. The risk of insolvency for the interest payments is discussed in section 11.5.

The risk of insolvency for financing a project is related to being able to gap the bridge between expenses and income. Since the construction costs have a large uncertainty, the financing reservation is also uncertain. The risk of insolvency is defined as the risk of not being able to finance the initial investments. However, reserving too much will increase the financing costs considerably. This then reduces the possibilities of using the financial leverage optimally, since equity is committed based on the total financing reservation. Recapitalization may then be needed. Reducing the reserved financing by 2 Mio € will yearly save around € 10.000 in commitment fees and € 20.000 in one time financing fees next to increasing the financial leverage. In Figure 51 the net present value of the financing reservation is given. From this figure follows that a financing reservation of almost 40,6 Mio€ would lead to a probability of insolvency of around 5%. In the case therefore a financing reservation of 41 Mio € is taken, given a risk of insolvency of around 4%.

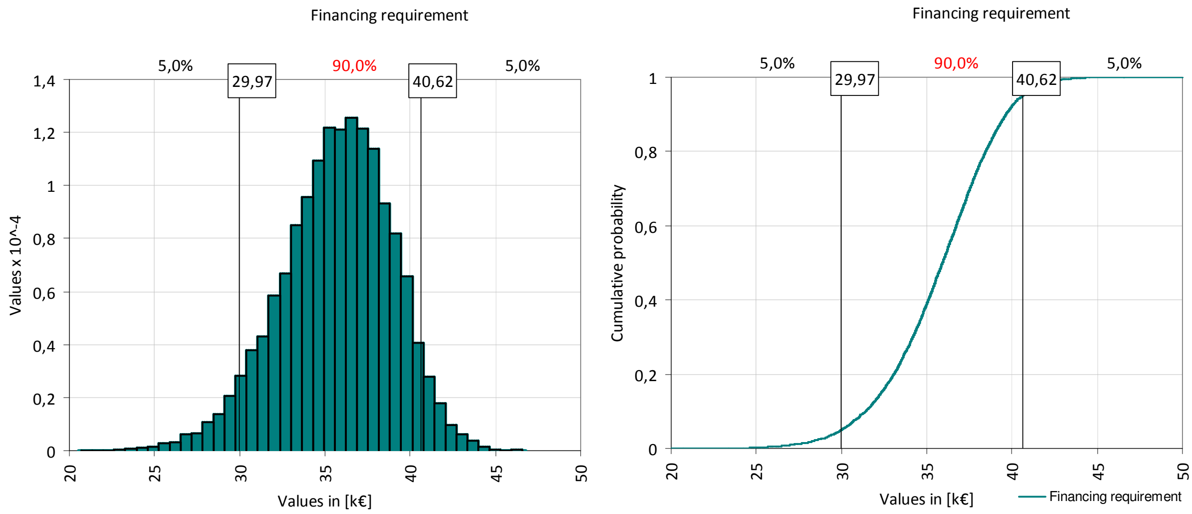


Figure 51 Distribution of the financing reservation for a 3 storey car park

Another aspect of financing a project is the reservation that needs to be made for operational expenditures during construction: the working capital. The working capital is required in order to finance the running accounts. The amount that needs to be reserved for the working capital is the difference between debtors and creditors. Payments to creditors should be completed within 30 days, for debtors 60 days should be taken into account until the payment should be received. The maximum difference between outgoing and incoming cash flows to creditors and debtors determines the working capital. In this case a working capital of € 1.000.000 is assumed. After construction the working capital is reduced to €100.000. In the time the working capital is needed for paying the running accounts, no investments are made with it or interest received on it. This will lead to opportunity costs discounted at the required return on equity. For example with a discount rate of 8,5% and a working capital requirement of € 1.000.000 this leads after 3 years to a foregone costs of (see Appendix VI:

$$1.000.000 - \frac{900.000}{1{,}085^3} = €295.000$$

It follows from a simple hand calculation in the appendix that the costs of working capital reservations can be considerable. Modeling the running accounts and minimizing the needed working capital can lead to significant cost savings.

The last characteristic of project finance that is discussed is the profit/loss made at the end of the project's lifetime. At the end of a project the construction still has a rest value. The construction can be valued in two ways:

- by the cash flow it can generate by continuing the exploitation; the market value
- by the value the construction represents and which it would cost to rebuild; the book value

The difference between the book value of the construction and the market value is a net incoming or outgoing cash flow. If this cash flow is positive it is an additional profit and if it is negative an additional loss.

The first bullet point is the market value. The market price of an asset can be valued by multiplying the last year's profit with a factor, called the EBITA multiple (Earning Before Interest Tax and Amortization). This multiple represents the number of year's profits that the construction costs. This multiple depends on the characteristics of the profit that is made and therefore can range from between 4 – 12 times EBITA. This idea is common for the valuation of companies. If the cash flow of the car park in this case study are considered an EBITA of at least 4 should be feasible. There is a high demand for parking spaces in the city of Amsterdam which would guarantee the cash flows. The forecasting models of car ownerships in the Netherlands predict for the near future a growth of the number of cars, which will increase the parking pressure. Next to this, creating new parking spaces in Amsterdam is difficult due to lack of space and high investment costs.
The bookvalue is determined by all investments made in the construction minus the depreciation. The difference between the market value and the bookvalue is an extraordinary profit or loss for the car park owner. For relative short project durations this can lead to a considerable increase in net present value. For longer project durations, the effect of the profit at the end of the lifetime reduces significantly due to uncertainty in the value and the discount rate over the project's life. After 20 years this extraordinary profit/loss has a NPV of:

$$\text{Expected Bookvalue} = €46.071.839 - €29.560.189 = €16.511.650$$

$$\text{Market value} = 4 * 4.954.000 = €19.816.000$$

$$\text{Etraordinary profit} = €3.304.350$$

$$NPV(8{,}5\%) = €646.000$$

This calculation is retrieved from appendix VI and shows that taking the extraordinary profit/loss at the end of the lifetime into account can have a large impact on the feasibility of a project. It could have a positive effect on the NPV, especially because of the high upfront investments, relative stable cash flows and good market position, which is the case for a car park in the center of Amsterdam. In the case study this effect is not considered.

In this section the results and simple calculation show the effect of financing in the case study. Next to this it indicates important financing and financial parameters which can influence the overall results significantly.

11.6 Technical, financing and market risk

In chapter 6 the categorization of the Basel II accords are described in which a risk for financial institutions can be divided into market risk and operational risk. Market risk takes into account the market situation which externally influences the project. In this section the differences between the approach of technical risk, financial risks and market risks are considered using the output of the model. At the end the relation between the risk categories is described.

In traditional technical cost estimations only technical risks were included in the valuation. Technical risk is included in the project valuation by including distributions for uncertain parameters and by estimating the effect of certain technical risks through a risk analysis. Technical risks that are included by giving a distribution to the parameters can be on (for application in the case see appendix III and V):

- Uncertainty on design parameters
- Uncertainty on unit prices
- Uncertainty in construction times

The second category of technical risks is the risk following from the risk analysis. With this analysis some risks can be identified and by quantifying them they are included in the valuation. In appendix IV a short risk analysis of the car park is given. In Figure 52 the distribution of expenditures for technical risks from the risk analysis are given. These are both caused by specific risks as by percentages of the initial CAPEX.

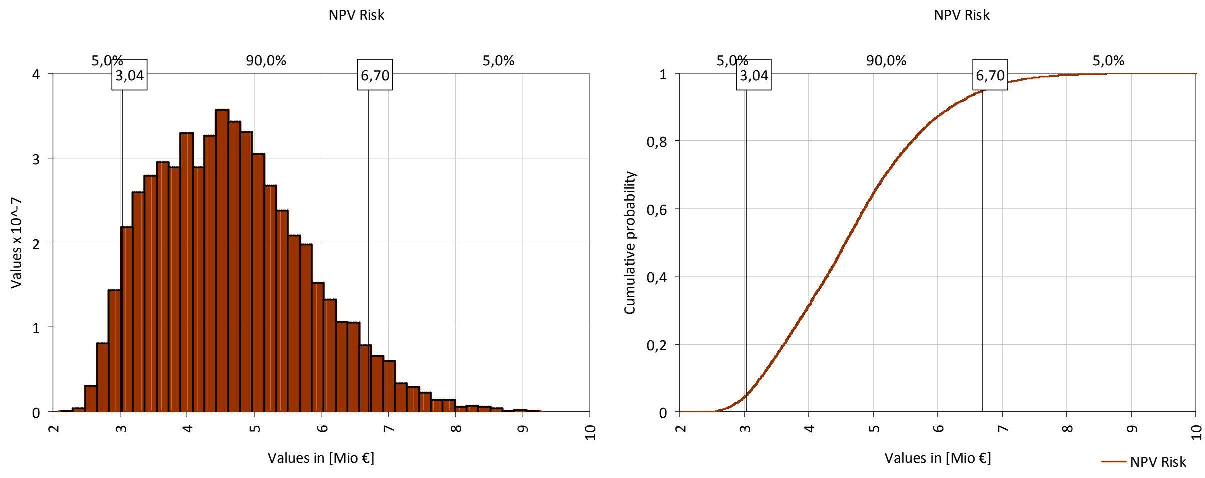


Figure 52 Distribution of the expected costs of risks

Financial risk include all the risks from financial parameters, directly related to the project. It focuses on the distribution on financial parameters and on the volatility of the cash flows. The risk of insolvency of financing is described in the previous section. Other financial risks are risks in financial parameters and the risk of insolvency of the debt service. The risk in the financial parameters is taken into account assuming a distribution of the financial input parameters (see appendix V).

The risk of insolvency of debt service is assessed by three ratios, as described in chapter 6:

- Debt Service Cover Ratio
- Loan Life Cover Ratio
- Project life Cover Ration

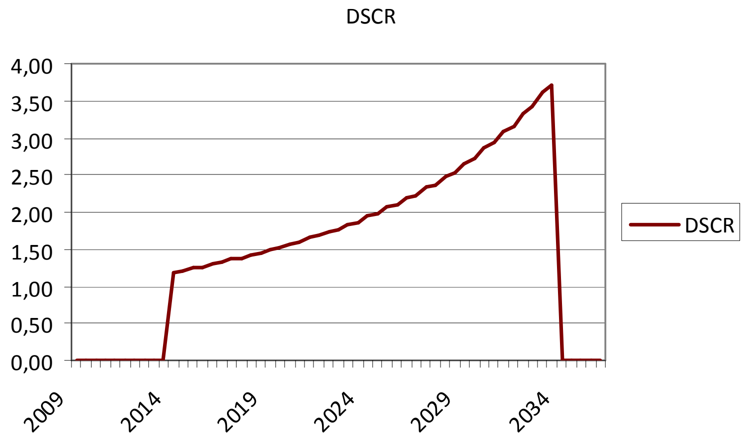


Figure 53 Debt Service Cover Ratio for the studied case

The debt service cover ratio (DSCR) is the most important ratio. This shows the coverage of the operating income to serve the debt service. Typically the DSCR of large infrastructure projects should be at least 1,10 – 1,20[9] depending on how stable the cash flow is expected to be. In more risky projects this value can go to 1,7. If these values are high enough over the project life, a higher leverage ratio could be used in the project, on order to increase the rate of return. Also the DSCR graph could be adjusted such that the peak at the end is distributed over the rest of the graph to see how much more debt service would be possible.
The values in the case study stay well above the presented threshold. This indicates that the risk of insolvency for this ratio is low enough. In the model the graphs of the other ratios are automatically generated. These are presented in appendix X. The values are all above commonly accepted threshold values.

Another indication of the financial risk of a project could be the distribution in the cash flows. In Figure 54 the cash flows per period simulated in the Monte Carlo simulation are plotted in boxplots. It can be seen from this figure that the distribution of the operating cash flows is the most volatile in the construction phase. The interest rates in this period are higher during construction than during exploitation because of the large risk. However, the cash flows in the exploitation phase are determined by a limited number of parameters and these parameters influence the project's outcome over a long duration. A possibility, which in practice is applied, would be to recapitalize. With a recapitalization the leverage ratio is adjusted to the amount of risk related to following period. Once more information is retrieved on the exploitation cash flows, they are expected to be relative stable and predictable.

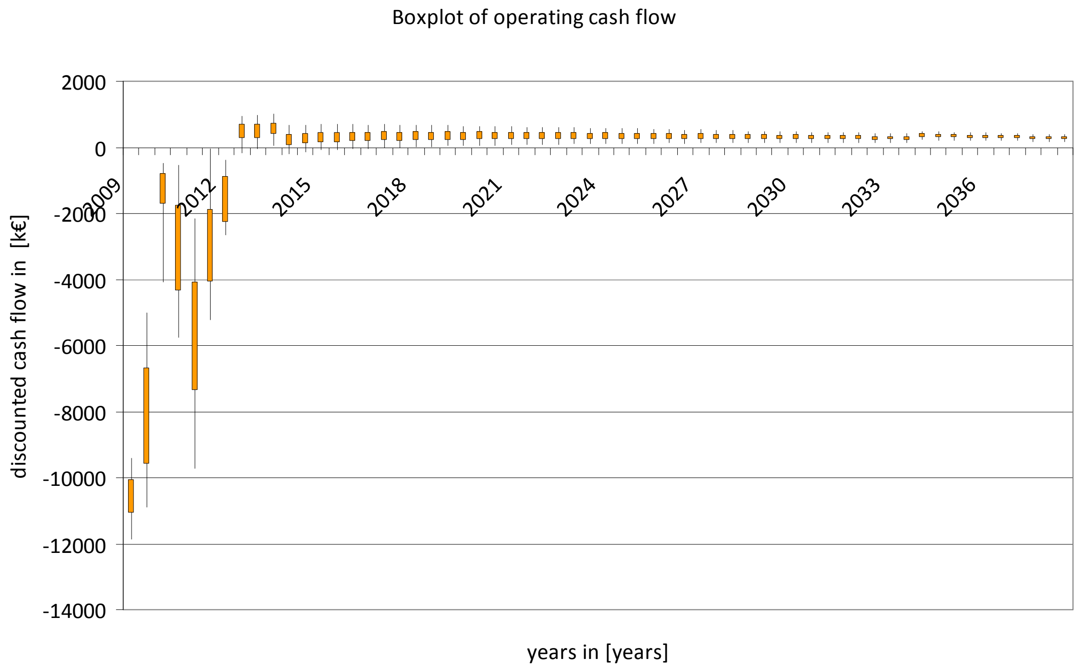


Figure 54 Spread of operating cash flows over the project life

Market risk consists of external financial risks, such as interest rate changes, changes in inflation, changes in prices of real estate property and other changes in the financial markets. In the case study the fluctuations in inflation and interest rates are not taken into account. The risk for interest rate fluctuation lie generally with the banks. For determining the relation between the risk group in the case study, the uncertainty in the interest rates and inflation was taken into account.

[9] website of John Laing plc, www.laing.com, retrieved 8-10-2008

The relation between technical, financial and general market risk is investigated using the simulation model of the case study. This research is done by grouping all uncertainty parameters in three groups:

- Technical (construction) parameters. This group contains all parameters related to the construction phase, both uncertainties in amounts and in price per unit for the design and construction are included in this group
- General market parameters. This group contains the interest rate (Euribor), rate of inflation and depreciation.
- Financial parameters. In this group the financial project parameters in the exploitation phase are included, such as occupation rate, hourly parking fare, license prices and ongoing CAPEX and OPEX for the different parts of the construction.

In each simulation probability distributions are assigned to one group parameters only, keeping all other parameters constant. This result is compared to the simulation with all parameters variable. The simulation when all parameters have a probability distribution differs from the base case, since in the base case it is assumed that there is risk of rising interest rates and inflation are not assumed. The risk of interest rate fluctuations is generally taken over by banks. Spread in the result due to different financing structures is not included in these simulations. The effect on the NPV and IRR is discussed in the previous section.

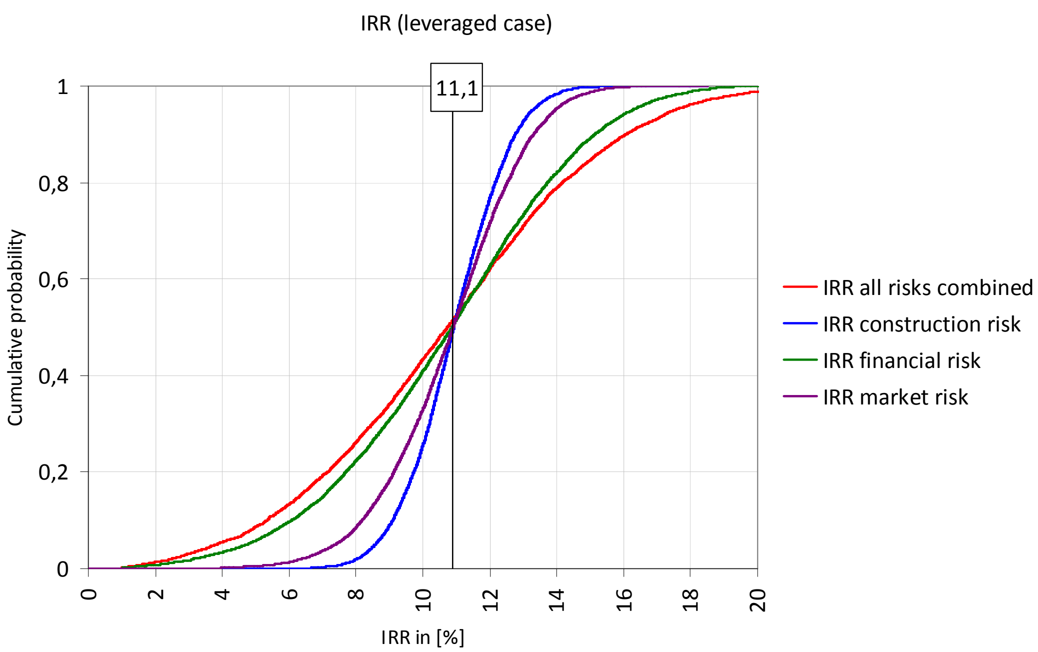


Figure 55 Distributions of IRR for different risk groups. For the occupation rate a N(35;7,5) is taken.

The results of Figure 55 suggest that the risks involved in the financial parameters are responsible for the largest share of the variation of the IRR based on the assumed distributions in the model. Next to this the market risk also causes a larger spread in the overall result than the technical risk. From the sensitivity analysis similar conclusions could be drawn by looking at the parameters influencing the NPV the most as shown in Figure 46. Figure 46 showed that the parameters having the highest regression coefficient with the NPV are financial and market parameters.

From the sensitivity analysis in section 11.3. followed that the occupation rate has the highest regression coefficient. The effect of a reduction in the spread in the occupation rate on Figure 55 is shown in Figure 56. In the figure below the N(35%, 7,5%) distribution for the occupation rate is replaced by a N(35%, 5%) distribution. The total spread of the IRR and the spread in IRR only with financial risks is reduced significantly. However it can still be concluded, that based on the assumed distributions, the uncertainties in the financial parameters causes a larger spread in the IRR than the market and construction parameters.

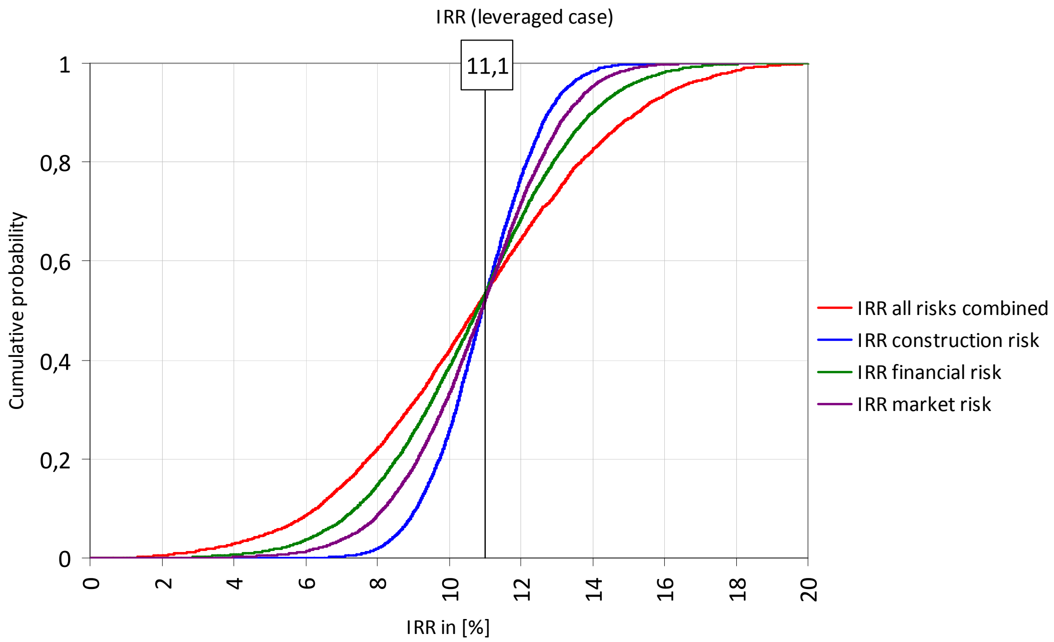


Figure 56 Distributions of IRR for different risk groups. For the occupation rate a N(35; 5) is taken

In this chapter….

The results from the simulations in the model are presented in this chapter. The base case is the case with a 3 storey car park, in which 464 parking spaces will be realized. The mean value of the total construction costs will add up to € 33,7 Mio. The NPV has a mean value of 5010 k€ and the IRR has a mean value of 11,1 %. In this calculation a WACC of 8,5% is assumed.

A 4 story car park has a higher NPV (€ 7500 Mio) and IRR (11,6%) than the 3 storey car park. The construction costs increase with €5Mio in comparison to the 3 storey car park. However the revenues from the additional realized parking space (610 parking spaces)compensate for the increased construction costs. Due to the increased height of the construction an additional risk reserve for geotechnical problems is included and an increase in strutting and heavier sheet piling is taken into account.

From the sensitivity analysis follows that variations of the occupation rates, rate of inflation and parking fare have the largest influences on the NPV. A reduction of the standard deviations of these parameters has the largest impact in order to reduce the spread of the NPV.

The effect of the financing structure on the feasibility of the project is significant. From the results follows that the technical side and the financial side of the project should be considered jointly to assess a project's value right. This conclusion can also be made when looking at the contribution of the different risks to the distribution of the project's outcome. The financial risk causes the largest spread, followed by the market risk. The spread due to the technical risk is the narrowest.

12. VALUATION OF FLEXIBILITY

12.1 Introduction

In this chapter the results of the study of the valuation of flexibility are presented. The results are the outcomes of the valuation model developed for this study, applying the different methods discussed in the part II of this thesis (chapters 4 – 7)

In this chapter the following results are discussed:

- Results of the valuation of flexibility using decision tree analysis (DTA)
- Results of the valuation of flexibility using binomial tree analysis (BTA)
- Comparison of results using decision tree analysis and binomial tree analysis.
- Value of flexibility of risk allocation

The extended description of the real option models with decision tree analysis and binomial tree analysis, are given respectively in appendix VIII and IX with underlying assumptions. With all options of developing multiple car parks, effect of reduction of costs through learning or scale effects are not included in this study. The most important modeling assumptions for both real option valuation methods are described shortly in the sections 12.3 and 12.4.

12.2 Real options cases

In this section the outcomes of the valuation using decision trees of three real options applied to this case are described. The valuation is done for a three storey car park, using the same assumptions as the base case described in the previous chapter. In appendix V the model input parameters of this case are listed. The real options described in this section are:

- Development of a second car park with the engineering and other preparations 1,5 year after the start of the development of the first car park. The decision of constructing the second car park is to be taken after 1 year of exploitation of the first car park. This real option would be the case if no exclusive right for the development of a second car park can be obtained.
- Development of a second car park with the decision on the entire development of the car park after 2 years of exploitation of the first car park. This real option would be the case if an exclusive right for the development of the second car park can be obtained.
- Development of the car park with the opportunity to redevelop the car park into storage spaces. In the case that the exploitation success after two years of exploitation is poor, the exploitation of the car park could be switched to exploitation as a self storage business.

12.3. Valuation with decision tree analysis

In this section the valuation of real options by applying decision trees analysis. With decision trees the possible courses of a project are modeled. In each branch of a decision tree the course of project are different, leading to different values of the project outcomes. With this method a decision on a real option in the project can be related to the prior project's course up until that point. The theory behind the method is described extensively in chapter 7. In chapter 12 the modeling of the decision trees is discussed applied on the three real options. In appendix VIII the decision trees and underlying assumptions and dependencies are described in detail.

The important underlying implication of the use of the modeled decision tree is that the NPV at the top of the tree is based on average expected values over underlying branches. In chance nodes the value at the node is determined by multiplying the values of each branch by its probability of occurrence. Therefore both the valuations in poor exploitation and successful exploitation influence the NPV at the top. So a value in a tail of the output distribution consists of the mean expected value of both successful and unsuccessful exploitation, given the project's course. The values in the left tail of the distribution thus do not represent only the results of poor exploitation success.

12.3.1. Real option of developing two car parks with early engineering

In the case no exclusive right can be obtained for developing a second, similar car park on a different location, engineering has to start early in order to be able to compete with competitors. This is modeled with a real option in which the engineering and project preparations start 1,5 year (phase 3; see chapter 8) after the project of the first car park is initiated. The decision on whether the construction of the project is executed is modeled to be after 1 year of exploitation of the first car park. If exploitation in the first year was successful, the second car park is realized. If the exploitation was unsuccessful, the realization of the second car park is cancelled. The costs of engineering and other preparation costs of the second car park are made in phase 3.

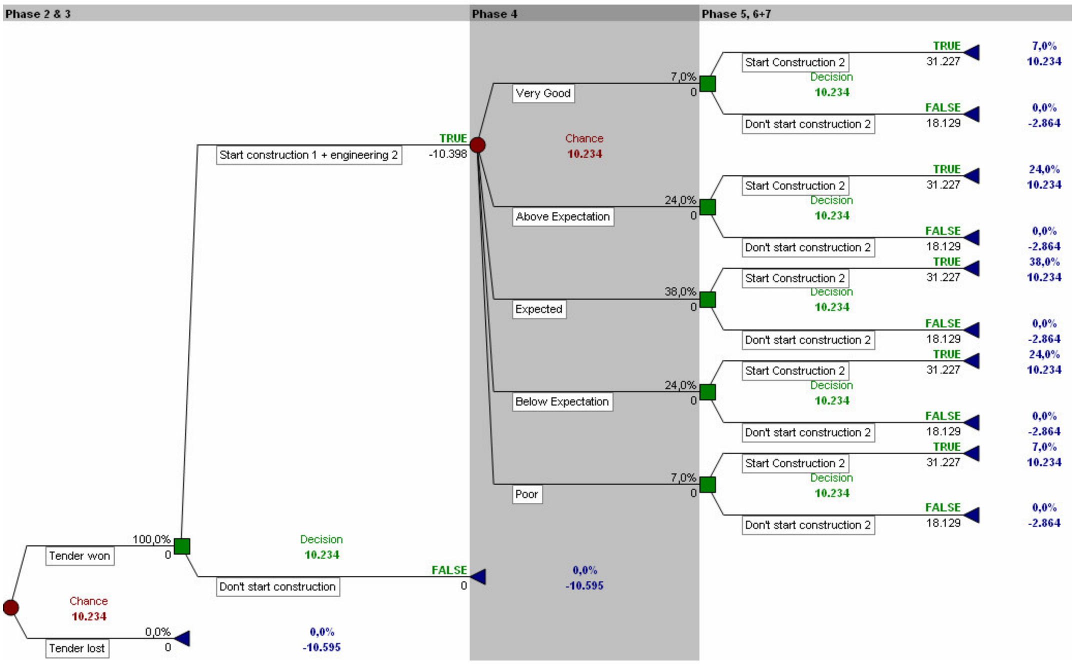


Figure 57 Part of the decision tree of the real option of developing two car parks with engineering in phase 3. For the entire decision tree see appendix VIII.

In this section the described option is compared to the standard NPV method in the case that the two car parks are developed right after each other. In the standard NPV valuation of the model it is assumed that the entire development starts after two years of exploitation of the first car park. The cash flows of the first and second car park are modeled to be the same, however shifted in time. Therefore the cash flows are discounted differently. In the standard NPV method no relation between the exploitation of the first car park and the decision of developing the second car park is taken into account. The difference between the two calculated NPVs is the value of the option of being able to develop a second car park under the assumptions described en the previous paragraph. In Figure 58 and Table 12 the results from the model are presented for this real option.

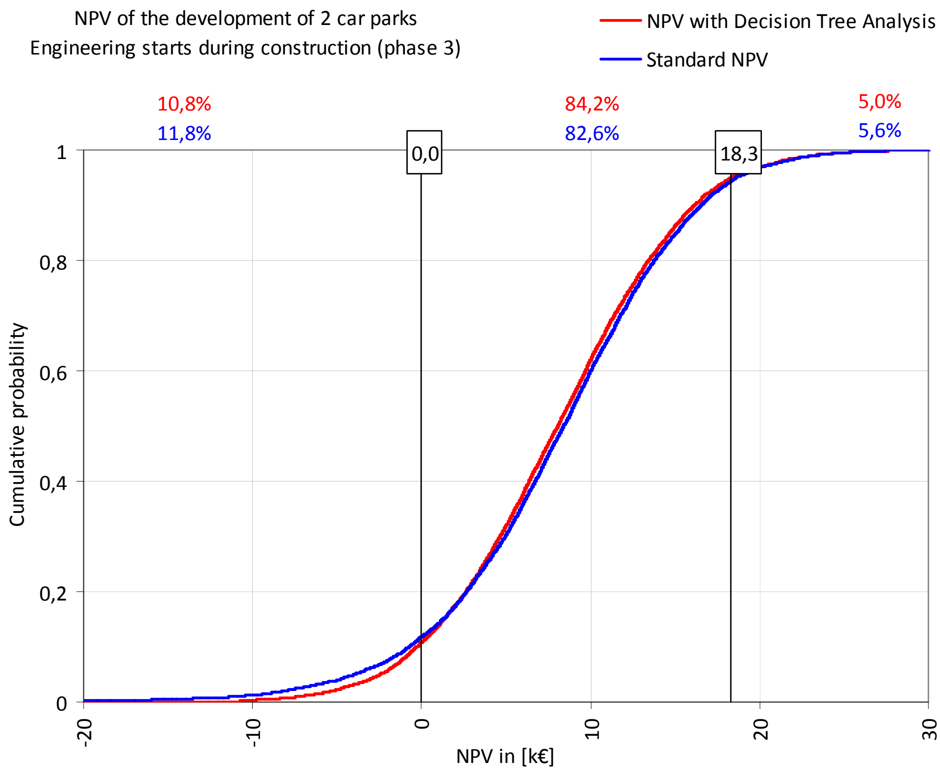


Figure 58 NPV of the development of two car parks with early engineering (DTA)

	Standard NPV	NPV with Decision Tree Analysis
5% - value	-4.000 k€	-2.500 k€
50% - value	8.400 k€	8.100 k€
95% - value	18.500 k€	18.300 k€

Table 12 Underceeding levels of the NPV of the development of two car parks with early engineering (DTA)

It can be seen from the results that the largest differences lie in the left-hand tail of the distribution. This can be explained by the scenarios in this tail. In all cases the initial costs of the engineering and other projects preparations are made. However in this part of the distribution the first car park is not successful. The total loss over two car parks is minimized by not developing a second unsuccessful car park.

At a certain point developing a second car park delivers a positive contribution to the NPV. From a tipping point the NPV of the early engineering costs cause the standard NPV to be higher than with the option. This is due to the fact that the costs of engineering the second car park are shifted to fall earlier and therefore reduce the overall NPV. Therefore the cumulative ascending probability curve lies further to the left in the rest of the distribution. This effect can be reduced if some of the engineering costs can be kept in the phase after the decision of developing the second car park is taken.

Overall it can be seen from these results that using the decision tree has two effects. The identification of this real option and valuation of it using decision tree analysis:

- narrows the width distribution of the NPV and therefore reduces the maximum loss. In this part of the distribution the maximum loss is lowered by around 1,5 Mio€
- lowers the mean expected NPV. The mean expected NPV is lowered by around 300 k€ due to the larger NPV of the upfront costs.

12.3.2. Real option of developing two car parks with engineering in phase 6

In the case an exclusive right on the development of a second and similar car park on a different location can be obtained, it is more attractive to postpone the decision on the entire development after information is available on the success of the first car park. This real option is modeled in this case with the start of the project after 2 years of exploitation of the first car park. If the first car park is successful in the start of the exploitation phase, a second car park is developed. If the first car park is unsuccessful, the development of the second car park is cancelled.

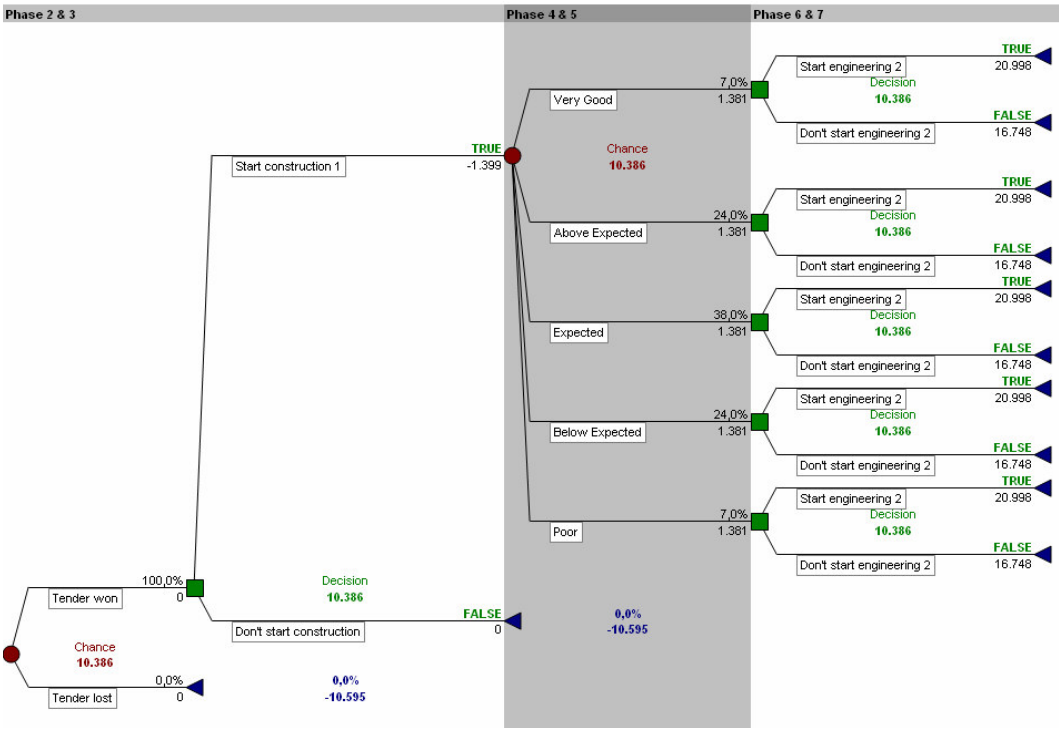


Figure 59 Part of the decision tree with the real option of developing a second car park with engineering in phase 6. For the entire decision tree see appendix VIII

In this section the previously described option is compared to the standard NPV valuation. In the standard NPV valuation in the model it is assumed that the entire development starts after two years of exploitation of the first car park. The cash flows of the first and second car park are modeled to be the same, however shifted in time. Therefore the cash flows are discounted differently. In the standard NPV method no relation between the exploitation of the first car park and the decision of developing the second car park is taken into account. The difference between the two calculated NPVs is the value of the option of being able to develop a second car park under the assumption described en the previous paragraph. In Figure 60 and Table 13 the results from the model for this real option are presented.

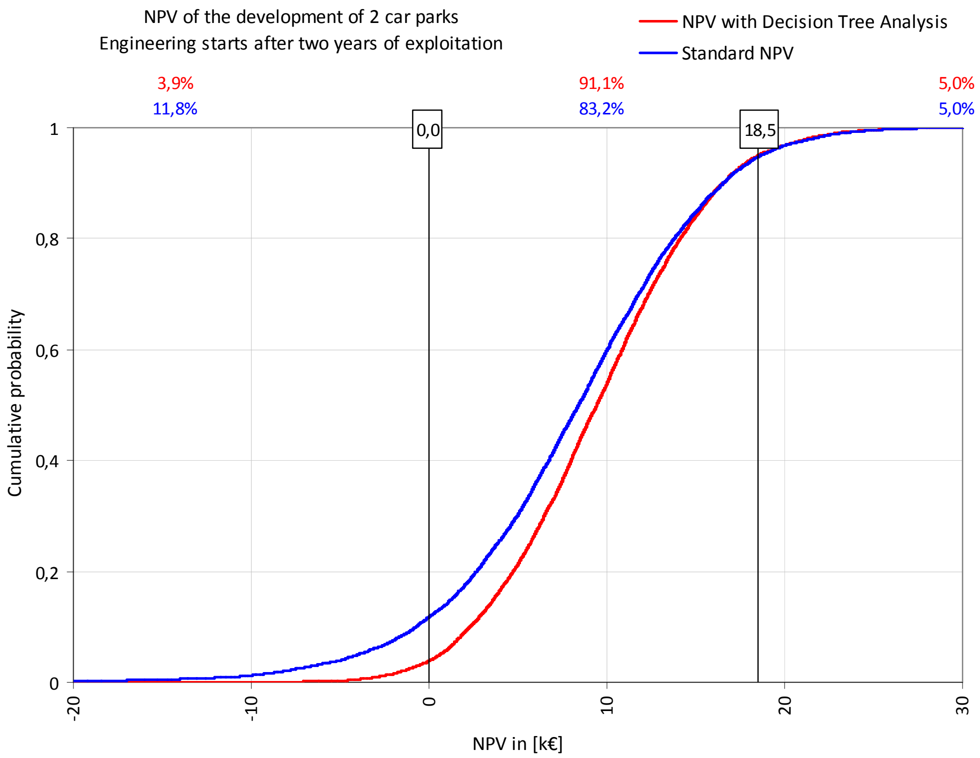


Figure 60 NPV of the development of 2 car parks with postponed engineering (DTA)

	Standard NPV	NPV with Decision Tree Analysis
5% - value	-4.000 k€	600 k€
50% - value	8.400 k€	9.400 k€
95% - value	18.500 k€	18.500 k€

Table 13 Underceeding levels of the NPV of the development of two car parks with postponed engineering (DTA)

It can be seen from these results that the option has a significant positive value over a large part of the distribution. Because all engineering and preparation costs are shifted after the decision on the development of the second car park is made, this results in a reduction of the expected loss due to poor exploitation success in the left-hand tail of the distribution. In the right-hand tail the values of the valuation using decision tree analysis and the standard NPV method result in approximately the same value.

12.3.3. Real option of switching to alternative exploitation

The third real option that is valuated using a decision tree analysis is the option of switching to alternative exploitation. In chapter 10 the exploitation as underground self storage was discussed. This real option is modeled such that after two years of exploitation there is a decision point on which it can be decided either to continue exploitation as a car park or to switch to the exploitation as underground storage spaces. This option is compared to the standard NPV valuation of the development of the construction as car park.

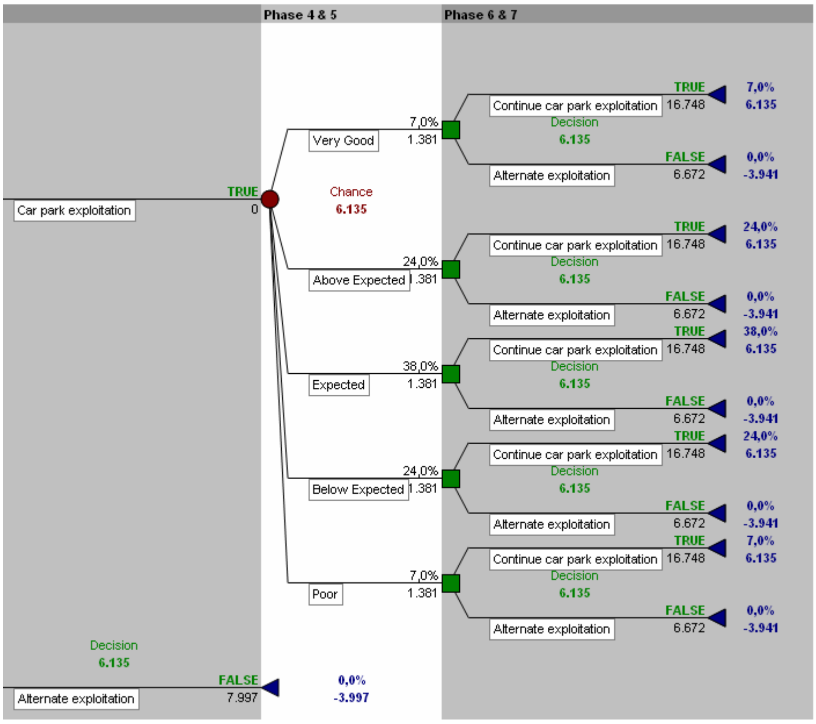


Figure 61 Part of the decision tree with the real option of switching to alternative exploitation. For the entire decision tree see appendix VIII

Several underlying assumption are made for the alternative exploitation. They are listed in appendix VIII. It is assumed that the costs of switching have a NPV of 1 Mio € and that the parking system can be resold for 80% of the initial price. It is further assumed that the spaces can be rented for 450€/m^2/year (assumed distribution of the prices of storage space downtown Amsterdam N(450;45)), which is according to current market prices for this type of business (15-20 euro/m^3/month). In Figure 62 and Table 14 the results from the model for this real option are presented.

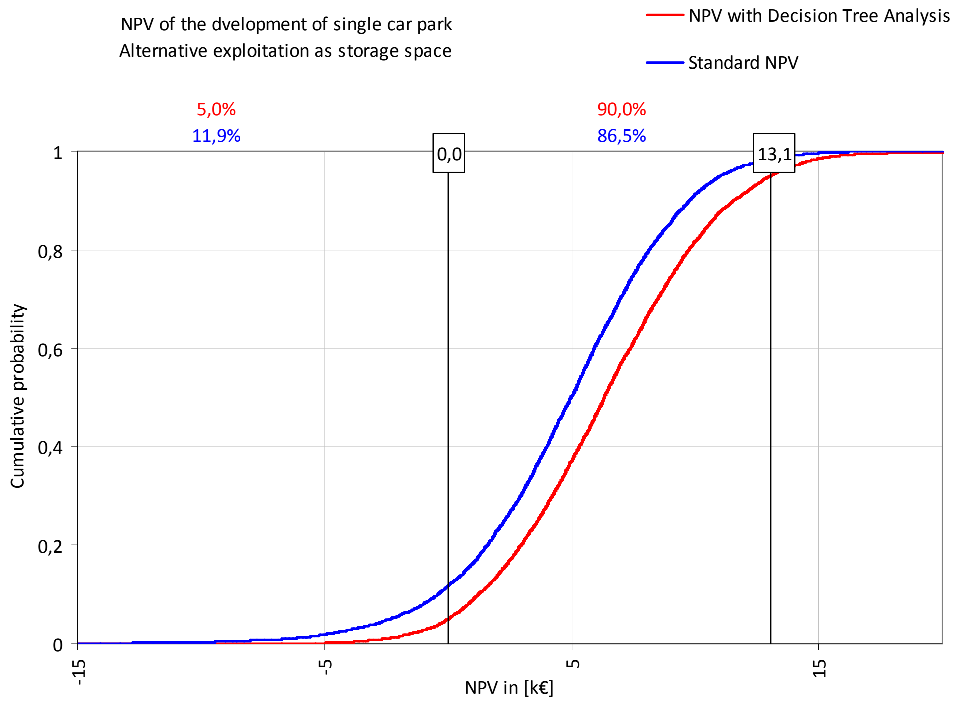


Figure 62 NPV of the development of a single car park including the option of alternative exploitation (DTA)

	Standard NPV	NPV with decision tree
5% - value	-2.300 k€	0 k€
50% - value	5.000 k€	6.300 k€
95% - value	11.100 k€	13.100 k€

Table 14 Underceeding levels of the NPV of the development of single car park including the possibility of alternative exploitation (DTA)

It can be seen from these results that the distribution of the NPV is shifted rightwards over the whole distribution. The mean expected value of the option is 1.3 Mio €. In this graph the effect of the averaged expected value at a chance node is visible. Using this modeling technique causes the whole graph to shift because the effect is on all scenarios. Therefore the option of shifting to alternative exploitation is included in each averaged valuation. If the chance node would have been modeled with a random generator, only the left-hand tail of the distribution would have been affected by the possibility of shifting to alternative exploitation.

12.4 Valuation with Binomial Tree Analysis

Binomial tree analysis is the second possible method that is described in chapter 8 for real option valuation. In this analysis all outcomes are aggregated neglecting path dependencies in the project's course. In this method all project outcomes are determined in the top tree. In the lower tree these values are reduced by subtracting the costs of that phase and multiplying them by the probability of reaching the next phase. Although this method is more useful for project with clearer phasing and less importance of path dependencies, the results in this chapter can facilitate a comparison of the different NPV-methods. The theory behind the method is described extensively in chapter 7. In chapter 12 the modeling of the binomial trees, applied on two real options, is discussed. In appendix VIII the binomial trees and underlying assumptions and dependencies are described in detail.

In this section the outcomes of the valuation using binomial trees of two real options in the case study are described. The valuation is done for a three-storey car park, using the same assumptions as used in the base case described in the previous chapter. In appendix V the model input parameters of the case are listed. The real options described in this section are the same as for the real options using decision tree analysis:

- Development of a second car park with the engineering and other preparations 1,5 year after the start of the development of the first car park. The decision of constructing the second car park is after 1 year of exploitation of the first developed car park. This real option would be the case if no exclusive right for the development of a second car park can be obtained.
- Development of the car park with the opportunity to redevelop the car park into storage spaces. In the case that the exploitation success after two years of exploitation is poor, the exploitation of the car park could be switched to exploitation as a self storage business.

In the binomial tree analysis the asset value in the top tree is determined as the mean expected value of the commercial cash flows. This means for example that in the real option of switching to alternative exploitation the cash flows are averaged over all scenarios by their probability of occurrence. In the poor scenario the commercial cash flows of the alternative exploitation are taken into account and in the case of successful car park exploitation the commercial cash flows of the car park exploitation.

12.4.1. Real option of developing two car parks with early engineering

The real option discussed in this section is the same as the real option in the case of the valuation with decision tree analysis. In this option no exclusive right for the development of the second car park is obtained. The engineering of the second car park starts 1,5 year after the project of the first car park is started. The decision on realization of the second car park is done after 1 year of exploitation of the first car park. If the exploitation is successful, construction of the second car park is commenced. The costs of engineering and other preparation costs are allocated in phase 3. In Figure 63 and Table 15 the results from the model are presented for this real option.

In modeling this real option the volatility of the outcome is defined as the yearly spread between the best case scenario and the expected scenario. Based on this spread the upper tree can be calculated using the method which is described in chapter 7. In the lower tree the costs of the project are subtracted for each phase. On the lower side of this tree, the costs for the poor scenario are subtracted. In the top the costs for a successful project's course are subtracted. If the NPV of the first car park is negative (in the poor exploitation scenario for example), it is assumed that the second car park is not realized. The costs of the second car park are then not taken into account. In that case in the lower part of the tree only the costs per phase of one car park are subtracted. The outcomes can be multiplied by a probability of reaching the phase. In this model all probabilities of advancing to proceed to the next phase are set to 1. This means that once the project is started the car park will be realized as well. Both the discount rate in the upper tree and in the lower tree is set to 8,5%. In appendix IX the trees are described more closely.

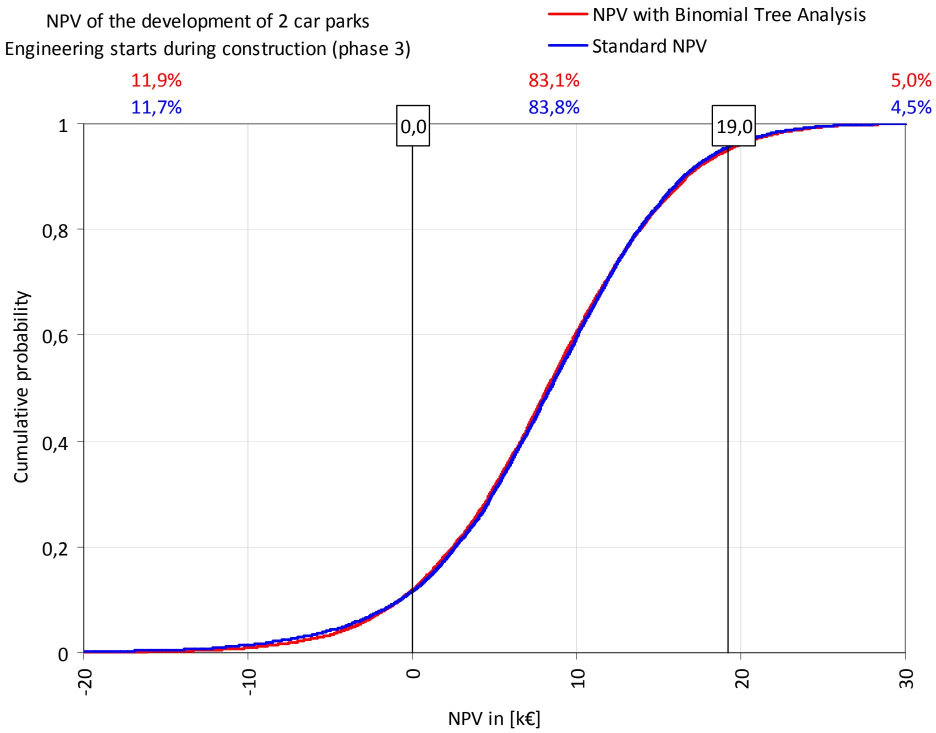


Figure 63 NPV of the development of two car parks with early engineering (BTA)

	Standard NPV	NPV with Binomial Tree Analysis
5% - value	-4.000 k€	-3.600 k€
50% - value	8.400 k€	8.300 k€
95% - value	18.500 k€	19.000 k€

Table 15 Underceeding levels of the NPV of the development o two car parks with early engineering (BTA)

The results above indicate that the binomial tree analysis results in approximately the same valuation as the standard NPV method. In both tails there are some slight differences. The mean value is approximately the same.

12.4.2. Real option of switching to alternative exploitation

The option of changing to an alternative exploitation is also studied using the valuation with the binomial tree analysis. In this tree the cash flows are modeled as if there is a decision point after two years after the start of the exploitation of the car park when can be decided to change the sort of exploitation. In the case the expected NPV of switching to a storage space business is higher than the expected NPV of continuing the exploitation as a car park. These costs and revenues are taken into account in the model. The underlying assumptions are the same as described in the case of the valuation using the decision tree analysis.

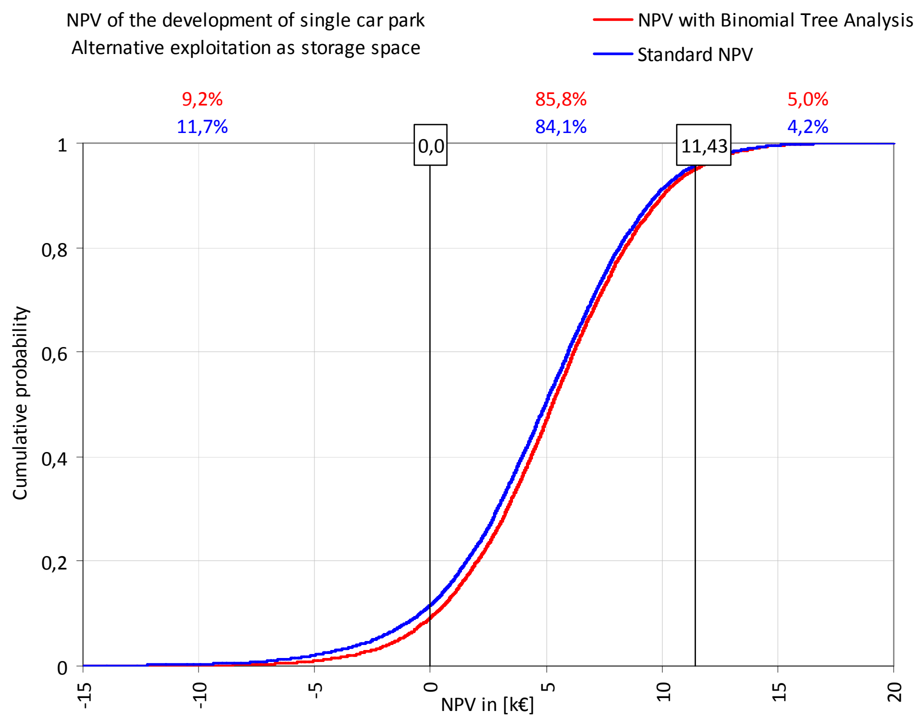


Figure 64 NPV of the development of single car park including the option of alternative exploitation (BTA)

	Standard NPV	NPV with Binomial Tree Analysis
5% - value	-2.300 k€	-1.360 k€
50% - value	5.000 k€	5.260 k€
95% - value	11.100 k€	11.400 k€

Table 16 Underceeding levels of NPV of the development of single car park including the possibility of alternative exploitation (BTA)

It can be seen in above figures that the option of an alternative exploitation as storage space business results in a rightward shift if the curve according to the binomial tree analysis. By including the exploitation as storage spaces the initial asset value is higher. This results in a shift over the whole distribution.

12.5 Comparison of NPV methods

In this chapter flexibility is valued using two different methods. From these results insight can be obtained in the value of valuing flexibility.

From the results of the valuation of flexibility using real option valuation it can be seen that valuation of flexibility can have significant value. If future decision points and project's courses are taken into account in the valuation a different NPV for the project is obtained. This additional value is the value of being able to decide on the exploitation based on a information resulting from a specific course of the project during the project.

In chapter 7 the theory and application behind the methods of the decision tree analysis and binomial tree analysis was described. From this discussion followed that decision tree analysis is more suited for civil engineering practice due to the less clear phasing of the project and the importance of path dependencies. If the results for the real option of alternative exploitation are plotted in one graph as in Figure 54 it is clear that the valuation using decision tree analysis values the flexibility the highest and results in a significant added value of the real option.

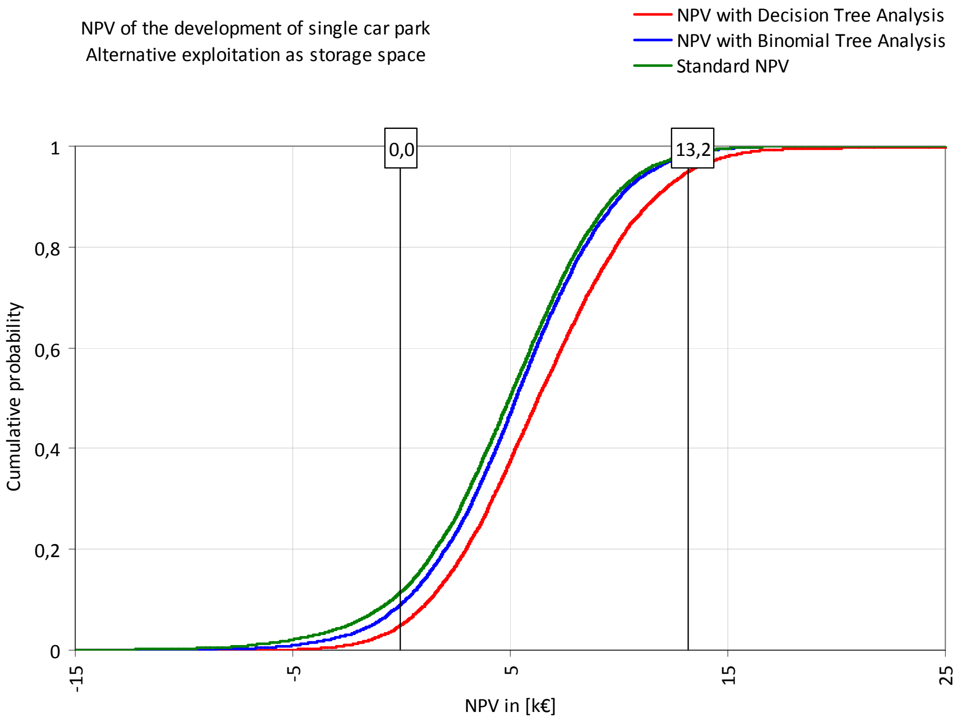


Figure 65 NPV of the development of single car park including the option of alternative exploitation (DTA&BTA)

12.6. Flexibility of risk allocation

In the risk analysis in appendix IV time periods are given in which the risk can occur in the project. In this section the flexibility in timing the risk reservation is researched. In the base case the risk reserves were allocated to the safest principle: the costs are modeled to fall at the start of the period over which they can occur. Other ways of allocating of the risk reserves are possible as well. For example the risk reserves can be modeled to fall in the middle of the risk period, at the end of the period or the risks can be modeled to have a probability distribution over the period in which they fall.

In this section the effect of allocating the risk reserves to the middle of the risk period is compared to the base case. In this case the risk reserves were allocated at the start of the period in which the risk could occur. By doing so the valuation of the risks overvalues the effect of the risks, however there can be discussion on the right way of allocating and valuating the risk reserves. In Figure 66 both NPV distributions are given. From these curves can be seen that shifting the risks further to the future can improve the feasibility. In the left-hand part of the distribution the value varies between 100k€ up to 500k€. Good risk management in which risks can be allocated to narrow time frames can result in an improved NPV versus the safest approach.

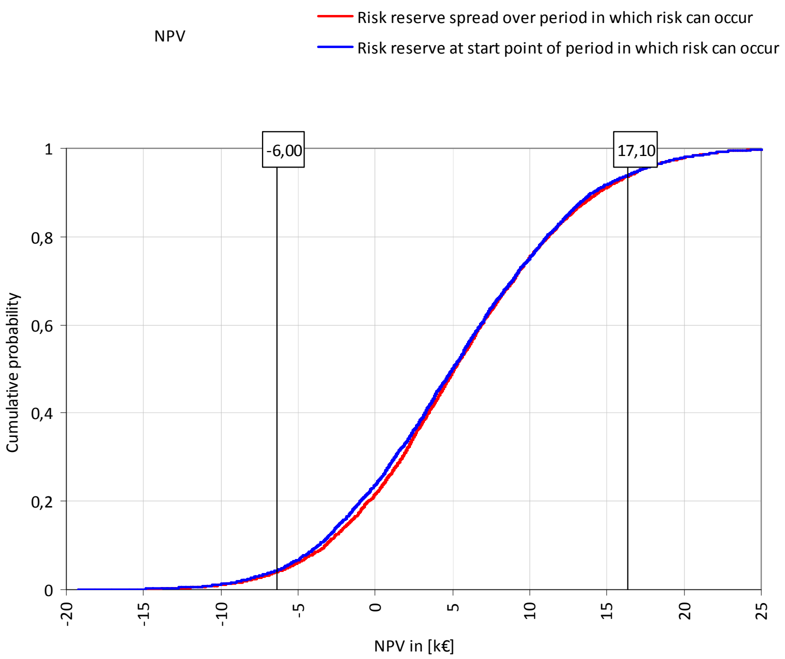


Figure 66 NPV of cases of risk allocation at the start of the risk period (blue) and spread over the risk period (red)

In this chapter….

In this chapter the results of the valuation of flexibility are given. The cases of real options that are valuated (developing a second car park with early and late engineering and the option of switching to alternative exploitation) are modeled both with the decision tree analysis and the binomial tree analysis. All options have significant value. In the case with the option of switching to alternative exploitation, the decision tree analysis values the project the highest. The binomial tree values the project slightly higher than the standard NPV method. The value of flexibility in risk reserve allocation has significant value as well. It pays off to consider the allocation of the risk reserves more closely.

13. VALUE CHAIN ANALYSIS IN CIVIL ENGINEERING

13.1 Introduction

In order to assess the possibilities for an engineering consultant as project developer and investor, the value chain of a civil engineering project should be analyzed. This analysis of the value chain of a civil engineering project is used as a context for this thesis. Each activity which is represented in a civil engineering project and thus in a Design, Build, Finance, Maintenance and Operate (DBFMO) project is considered separately by investigating the companies active in that step. In section 13.2 the structure of the value chain analysis is described. In the following sections characteristics of the value chain are described. In section 13.3 the profit margin is analyzed. Section 13.4 the value added in each step. Section 13.5 summarizes the market prospects as seen by the largest players in the civil engineering value chain. In the last part of the chapter (section 13.6) the exposure to market risk and general market fluctuation of each step in the value chain is discussed using the parameter beta of the CAPM (see section 4.5 for description of the CAPM).

13.2. Value chain of a civil engineering project

From the design stage of a civil engineering construction until the end of the life cycle multiple actors are involved in a civil engineering project. More of the civil engineering value chain is shifted to the private sector with innovative contracts. These new forms of tendering shifted market relations and negotiation power. In this part of the study the different steps of the value chain of civil engineering project in the current construction market in the Netherlands are investigated. This chapter covers the earning potential, added value, market prospects and market risk of each step of the value chain, in order to facilitate positioning inside this value chain.

Civil Engineering projects are large and complex projects. Multiple independent activities can be identified in a project in which businesses can specialize themselves. In a Design, Build, Finance, Maintenance and Operate (DBFMO) project the largest part of the value chain lies with the private sector. Initiation and demolition of the construction remains with the public sector. The other steps in the lifecycle of a construction are outsourced to the private sector. In this study the categorization of the value chain of Figure 67 is used. This categorization covers all the responsibilities that can be identified in a DBFMO contract. In Figure 67 the activities of the value chain are described and the part of a DBFMO project is given between brackets.

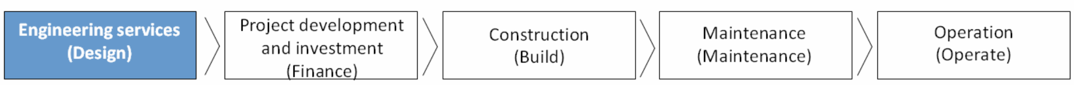


Figure 67 Activities in the civil engineering value chain

- Engineering services and engineering consultancy (Design in DBFMO): After initiation by a project developer or by a public party, a civil engineering project starts with a feasibility study and design work. All engineering work is assumed to be included in the engineering services.
- Project development and investment (Finance in DBFMO). The project developer takes the decision on the realization of the project. By investing with equity in the project, the developer takes the role of investor and actively takes on the risk of the project. Net revenues from the project repay the investment.
- Construction and maintenance of the construction (Build & Maintenance in DBFMO). After realization of the project, the maintenance starts in the exploitation phase. In annual reports construction and constructive maintenance is described by the same business group. Therefore in this study construction and constructive maintenance is grouped. Construction is divided in general construction and infrastructure. All activities related to the technical installations are not included in this study.
- Operating activities (Operate in DBFMO): Facility management makes the execution of the main function of the construction possible. In the contracts the facility services required for the construction can be stated, such as security, catering, cleaning of furnishing. The construction can be exploited by a third party for operating activities.
- The life cycle of a construction is ended by the demolition or the reuse of the construction. In this study this phase is not considered.

In this chapter the characteristics of each step of the value chain is studied in order to determine in which step of the value chain a company can optimally utilize its resources. To get insight into each step of the value chain this section discusses:

- The profitability of each step
- The value added in each step
- The market prospect
- The market risk

The analysis of the value chain is done by studying companies which are active in each part of the civil engineering value chain. The companies investigated are described in appendix XIII. The study is done primarily by using the annual reports over the last three years of these companies. Next financial data are retrieved from a financial database, the Thomson ONE banker. The above characteristics of each step are studied by analyzing respectively for each step:

- “Earnings before Tax”– margin (EBT-margin)
- value added per employee and total value added
- Market prospects on the construction market
- Market risk by studying the CAPM beta

This approach has some implicit conditions and assumptions:

- The research is limited to Dutch companies. Foreign companies will work under different market conditions. This may influence the results, since the market power may lie differently in each country and therefore the profitability. Although it is tried to include only Dutch activities most companies are working internationally. This will induce errors in the outcomes due to results from abroad.
- The research is based on the information available in the annual reports. Since each company differs in the amount of information shared in the annual reports, this may result in incomplete information. In some parts of the study this means that fewer companies are included in the study.

- The number of companies in the research is limited. The results presented in this section give insight in the characteristics of each step of the value chain. The study does not give general holding values for each step of the value chain.
- In the financial report results of foreign activities and Dutch activities are summed over each step of the value chain. Lack of information on segmentation to geographical origin of the results per step of the value chain prevents the determination of only Dutch activities per step. Market conditions abroad will influence all results.
- The results in the financial reports cover the whole range of projects. Because of this fact the analysis in this section is for the entire construction sector. Each company may have a focus or expertise in a different field of the construction market. Activities in one field of expertise however can show higher margins than expertise in other fields. For example, very specific engineering services will yield a higher margin than standard engineering services for standard projects. Therefore this analysis gives a rough overview of the value chain over the whole range of civil engineering projects.

13.3. Earnings before Tax margin (EBT-margin)

13.3.1. EBT-margin over the value chain

The EBT-margin shows what profit is made before taxes are subtracted per Euro turnover. This margin shows the part of each Euro that comes into the company for the services provided. Higher margins for comparable companies indicate higher profitability for similar services. This can indicate that the revenues from the services provided can be sold for a higher price to third parties or less operational costs are made in comparison to the competitor considered. The margin also depends on the pricing power which in return depends on the market type. The EBT-margin includes both the profit from operational activities of the company and income from financing operations (see Figure 68 for the relation between definitions in the profit and loss account). The EBT-margin can be calculated by dividing the earnings before tax by the gross revenue. In appendix XIV the financial figures of the studied companies are given.

Gross Revenues		
	Costs of third party services/project expenses	
	Costs of goods/materials purchased	-
Value Added		
	Employee expenses	
	Depreciation and Amortization	
	Other operating expenses	-
Operating profit (EBIT)		
	Net financing result	-
Earnings before tax (EBT)		
	Tax	-
Net Result		

Figure 68 Simplified overview of income statement (with added value and EBT)

A second indicator of the profitability is the EBT margin on value added. This ratio shows how much of each Euro value added contributes to the earnings before tax. For example for engineering services this means what percentage of profit is calculated per Euro invoiced for services provided directly. Cost of services and materials of third parties are charged directly to the customer. However this ratio does not take the differences in the use of the factors of production into account. For some activities large amounts of capital are required which results in higher EBT per value added ratios. The figures of each company are listed in appendix XIV.

In this study the EBT-margin is chosen over the more common EBIT-margin (Earning Before Interest and Taxes) to make a comparison of the steps in the value chain possible. Engineering consultants and construction companies receive the majority of their income via operational activities. However the income of project developers, construction and infrastructure can have significant results from the financing activities.

In Figure 69 the results of the 32 investigated companies are shown (for derivation of the graph and figures per step of the value chain see appendix XV). To get insight in the volatility of the margins and movements in the markets the EBT-margins over the last three fiscal years are shown. On the horizontal axis the activities in the value chain of civil engineering are listed. Some considerations on this graph are:

- Since the figures of real estate development and construction are not listed separately in the annual reports of some construction companies this activity is graphed separately between project development and construction.
- Although the emphasis of PPP-projects is generally on infrastructure and public real estate, the category project development contains dominantly commercial real estate. This is due to the effect that the turnover of commercial real estate is much larger than the turnover in PPP-projects. However, no insight is given if the margins of commercial real estate are comparable to the margins in PPP projects. Of the companies investigated only BAM PPP presents numbers in the fiscal report (see appendix XIV). For the rest no data is included in the study.
- The category construction is largely influenced by the activities of the BAM. However in 2005 the BAM did not report separate financial figures for the construction part which influenced the EBT-margin for construction. In 2006 a negative result of the BAM is the reason for the almost 0% margin.

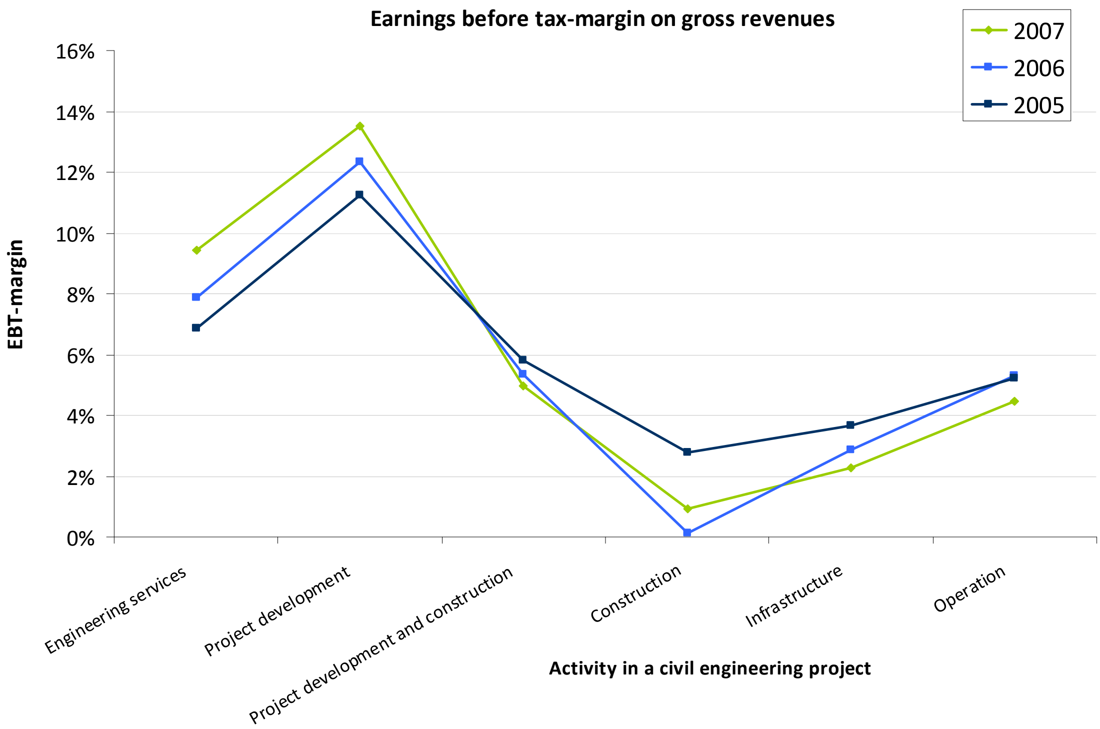


Figure 69 Earning before tax margin on gross revenue per activity in the civil engineering value chain

From this graph some movements can be visible:

- The margins for engineering services and project development are considerably higher than for construction, infrastructure and operation.
- The margins for engineering services and project development increased over the last three years. The margins for construction, infrastructure and operation decreased.
- The project developers considered in this study, have higher EBT margins than the companies with engineering services.

13.3.2 EBT-margin for engineering consultancy

An engineering consultant should focus on the projects in which the expertise is the highest. In these fields of interest the company has a competitive advantage over its competitors. The EBIT margin can give insight on the fields in which the engineering consultant has the most expertise. In the table below the EBIT margins for three domains of civil engineering are given. From this table follows that Royal Haskoning has relative high EBIT margins in the fields of building and utility construction and in the field of infrastructure and transport.

Engineering services

Company	Buildings and utility construction		Infrastructure & Transport		Water and Environment	
	EBIT-margin	Revenues	EBIT-margin	Revenues	EBIT-margin	Revenues
Arcadis (2007)	5,7%	351	5,1%	622	8,0%	537
Royal Haskoning (2007)	7,1%	42	7,1%	16	1,5%	25
Grontmij (2007)	5,1%	270	6,8%	193	6,8%	309
Weighted average (%)						
Total (Mio €)	5,4%	621	5,5%	815	7,6%	846
Fugro (2007)	Geotechnics		Survey		Geosciences	
	14,3%	442,5	19,7%	852	18,5%	508,2

Table 17 EBT-margin per field of expertise of engineering consultancy firms

13.4 Value Added

The value added by a company is the additional value that is contributed to the product using the factors of production land, labor and capital. The value added shows how much the company contributes to the value chain. The value added can be calculated by subtracting the costs of the purchased services and goods from the gross revenues (see Figure 68). Value added can also be calculated by summing the operating profit, operating expenses, depreciation and amortization and all employee expenses. The added value can be summarized as the costs per employee for wages and the use of other factors of production.

The value added per company from the financial figures is presented in appendix XVI. Not all companies provide sufficient information in their financial reports to calculate the added value per step of the value chain. Therefore the numbers of companies included in this part of the research is smaller (see appendix XVI and XVII).

The value added divided by the number of employee gives insight in how much one employee contributes to the value chain using the factors of production. The total value added per step of the value chain offers insight in the relative value added of each step of the value chain.

13.4.1. Value Added per employee

In Figure 70 the results of the 21 investigated companies are shown (for derivation of the graph and figures per step of the value chain see appendix XVI). To get insight in the volatility of the value added and movements in the market, the value added per employee over the last three fiscal years is shown. On the horizontal axis the activities in the value chain of civil engineering are listed. Some considerations on this graph are

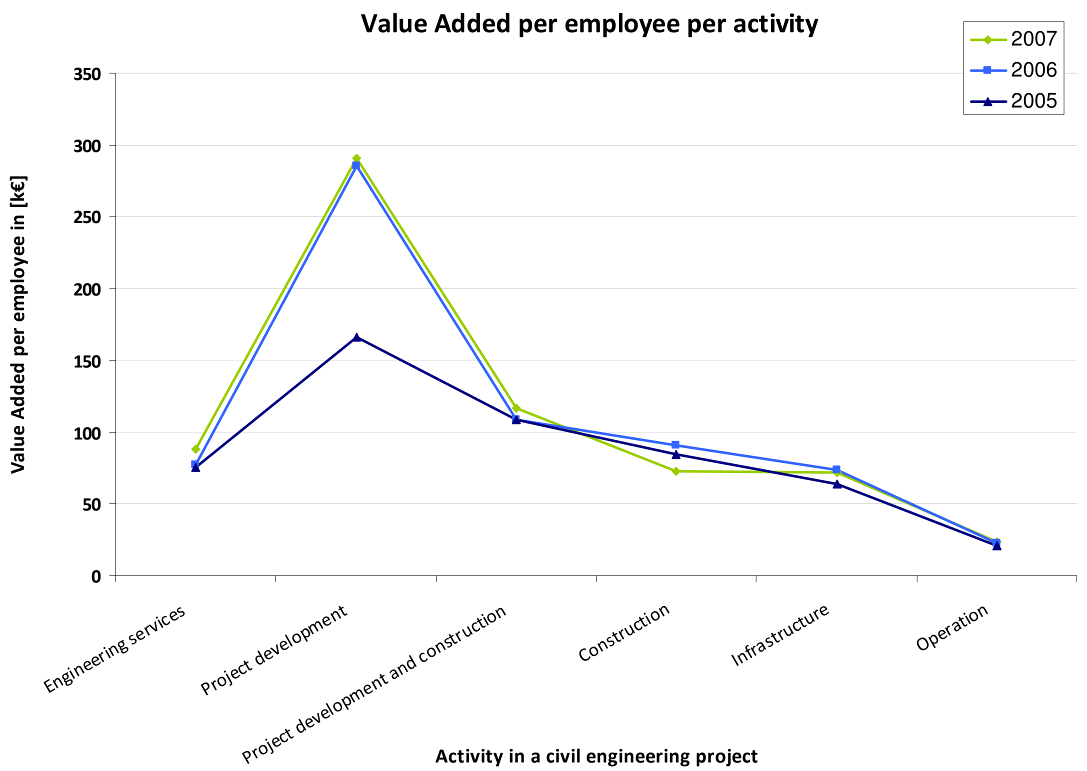


Figure 70 Value Added per employee per activity

- The value added partly depends on the price level for the factors of production and therefore products in a particular market. For companies acting internationally this means that a service with the same EBT-margin can have a lower value added than the same services in home markets. If the total value added by a company is divided by all employees, this may result in lower value added per employee.
- The value added per Euro turned over in the project largely depends on the sort of project. Projects with large share of the factor of production labor will show a high value added/turnover ratio. Projects in which large capital investments are needed this ratio will be significantly lower. In this study all sorts of projects are aggregated which can cause deviations from the real number in a special field of expertise.
- The value added per Euro turned over in the project also depends on the pricing power of the considered companies. The pricing power depends in return on the market characteristics. If companies have very specific expertise a higher value added per employee is possible.
- The number of companies in some phases of a project is small because the limited amount of available information. This can cause deviations from the real value added in practice. For the figures of the studied companies see appendix XVI.
- The market structure for construction and infrastructure can influence the result due to the use of large numbers of subcontractors. In this study the 10 largest construction companies plus 1 are considered, with revenues as criterion. These construction companies use a large

number of smaller subcontractors. This will result in a large revenue, however also in a relative low value added. This effect is expected to be larger for normal construction than infrastructure construction, due to the number of subcontractors working in that field. The infrastructure construction market is a little bit less fragmented than the normal construction market.

In the graph in Figure 70 can be seen that:

- The value added per employee of the considered project developers is considerably higher than in other activities in the civil engineering value chain.
- The added value per employee for engineering services and project development increased over the last three fiscal years. The added value per employee for the other activities remained approximately constant.

13.4.2. Total Value Added

The total value added per step of the value chain offers insight into which part of the value chain value is added to construction projects in the Netherlands. The size of the value added per step of the value chain shows where a project gets its value from.
The determination of the added value is done in multiple steps. By calculating the average added value per gross revenues a ratio is obtained of the amount of value added per step. If this ratio is multiplied by the total estimated market size, the value added per step of the value chain is obtained.

The ratio of value added per gross revenues is a measure of the use of the factors of production. The factor labor generates relative much added value per revenue. For the factors capital and land the added value per Euro turnover is generally lower. For the determination and derivation of the graph the same considerations as in section 13.4.1 hold. For the derivation of the graph and figures per company per step of the value chain see appendix XVII.

It can be seen in Figure 71 that operation and engineering services are using considerably more labor than the other activities. The ratio of value added per gross revenues for project development is largely influenced by the figures of ING real estate. Other project developers have generally lower ratios, usually slightly over 10%.

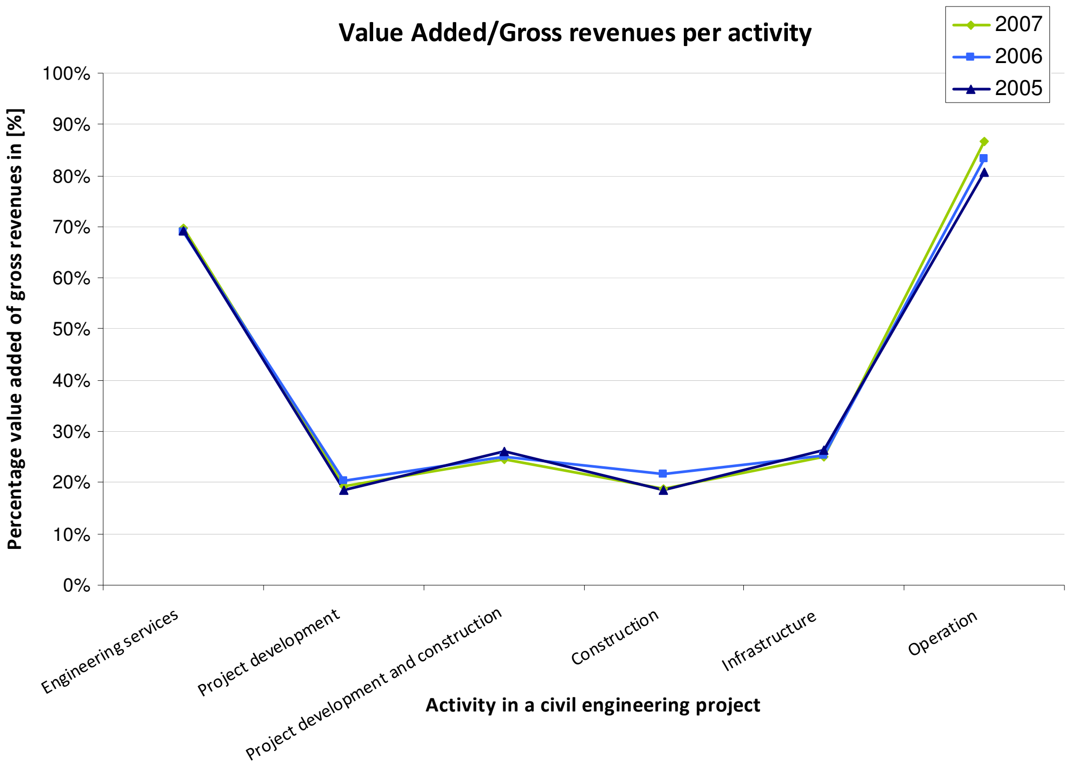


Figure 71 Ratio value added on gross revenues per activity

To estimate the total value added per activity, the total market size in revenues should be estimated. The total market for engineering services can be estimated at 6500 Mio € by summing the revenues of the largest consultant engineers (see appendix XIII section 3.1.).
The total markets for construction and infrastructure can be derived from combining data from the CBS and distribution of revenues with the 10 largest Dutch construction companies. From total revenues in the construction market and the growth rates, published by the CBS, the total revenues in the construction market can be calculated. The results are shown in Figure 72.

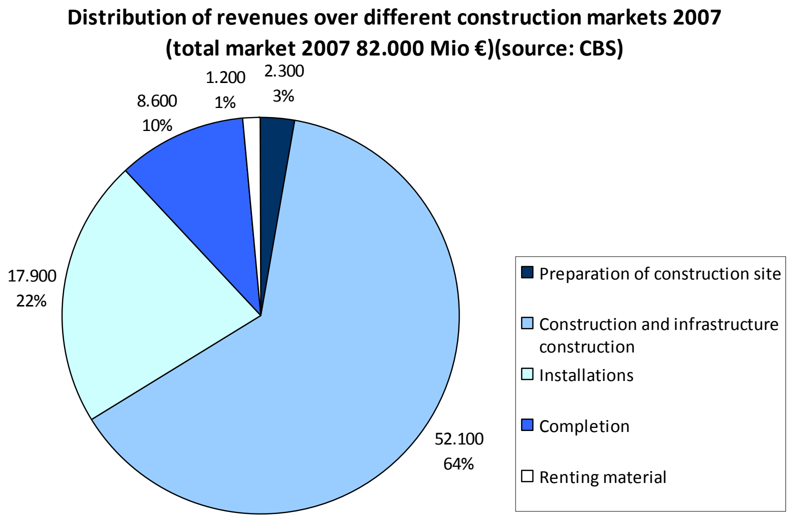


Figure 72 Distribution of revenues in the Dutch construction market 2007 (source: CBS)

In this study and in the financial reports a different categorization is used. It can be seen in Figure 72 that the posts construction and infrastructure add up to almost 55.000 Mio€. The distribution between construction and infrastructure is retrieved from the distribution of revenues of the ten largest construction companies on the Dutch market (see Figure 73). If project development and construction is divided into 25% project development and 75% construction (figures Ballast Nedam), then the revenues from construction and infrastructure can be estimated.

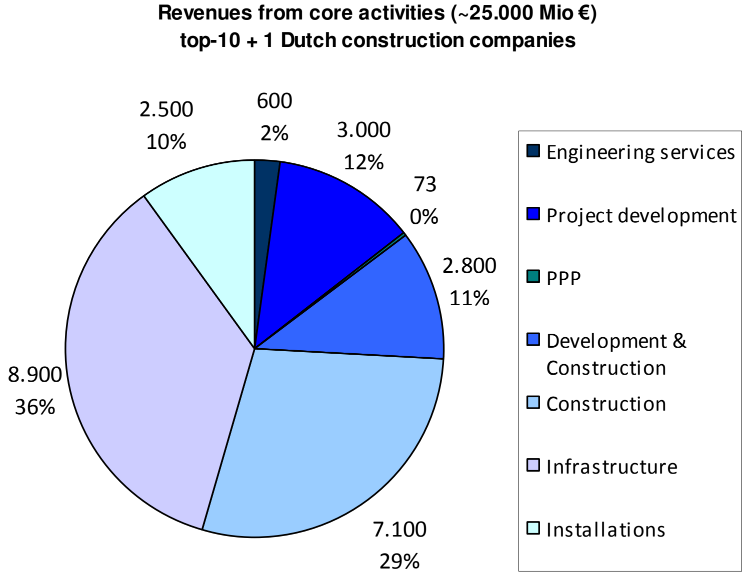


Figure 73 Distribution of revenues of the 10 largest construction companies + 1

The total revenues of new developing activities by project developers are difficult to determine. Estimated is that this market is approximately the size of the construction market. The rest of the financing activity is done by private companies developing own projects and by governmental project initiators.

Data can be obtained from the CBS that the large construction companies hold a share of approximately 37% of the construction market.

	FTE	Revenues	#	Market share
Large companies	> 100 FTE	>40 Mio€	430	37%
Intermediate	10-100 FTE	4 - 40 Mio €	7740	41%
Small companies	1-10 FTE	< 4 Mio €	77000	22%

Table 18 Distribution of companies on the construction market

Combining the above mentioned results, we get an estimation of the absolute size of the value chain in Table 19.

	Engineering services	Project Development	Construction	Infrastructure
Market size (Mio €)	6.500	30.000	30.000	25.000
Added value/Revenues (%)	70%	19%	20%	26%
Total Added value	4.550	5.700	6.000	6.500

Table 19 Market sizes and Value Added

13.5. General market overview and prospects

Qualitative statements in each company's annual report on the recent market developments and future prospects give pointers on the market situation. Current situation and movements are presented on each step of the value chain. The market situation and market prospect give the boundary conditions on how the future value chain of civil engineering will look. Future market conditions are an important factor in how attractive each step of the value chain is for doing business.

According to the CBS[10], the Dutch construction market grew by approximately 10% in 2007 to over 80 Bio €. In previous years this growth had only been 3%. The growth in revenues from utility constructions was 10%. For infrastructural works the growth in 2007 had been 7%. The CBS reports that the rise in revenues in the construction sector went together with a rise of construction costs of 4% in utility construction and a 5% rise in infrastructural construction.
Rabobank published their expectations for the construction market just before the effects of the global financial crisis became apparent. Rabobank[11] added to the growth numbers of the CBS that the growth in 2008 will be reduced to an overall growth rate of 7%, of which almost 4% in construction costs increases. The revenues are threatened by increasing prices, wages and a shortage of qualified construction personnel. The growth rates are based on the demand for new constructions and housing, initiation of projects and realization of already initiated projects.

The best visible movement in the construction market is forward and backward integration of construction companies over the value chain [9]. Construction companies focus on services both in project development and engineering services and in facility management and other operation activities. This way integrated solutions over multiple step of the value chain are offered.

The total number of new developed constructions will fall for both utility constructions as infrastructural works [12][9]. This reduction is caused both by long term tendencies of the market, increases in constructions costs, less expected public investments ([15], 2008) and the current global financial situation. Next to the number of projects, the construction and infrastructure sector are facing a price competition. This will lead to an expected drop of margins in construction and infrastructure construction in the next years. Prices of material and wages are expected to increase. These increases are difficult to be charged to the customer. To overcome the price competition a forward and backward integration is visible.

The global financial problems affect the construction and especially the real estate markets, according to recent publications. The branch unions for project developers NEPROM and NVB state that the demand for new constructions remains[13]. Because the financing is difficult to arrange only the best projects will be constructed which will reduce growth. However, when the financing problems are resolved, growth could be reinstated. In the short term the crisis could lead to a shortage of housing, which could raise housing prices again. The NEPROM and NVB expect that the number of houses to be constructed will reduce from 80.000 this year to 50.000 in 2011.

The annual reports of the different construction companies show the same movements as the above described. The BAM group reports high pressure on margins due to rising commodity prices, subcontractors and suppliers. Next to this the market for employees is tensed and regulation is difficult. Prices increases are expected to continue over the next years. Because of continuous price increases, offers are not inside budget constraints of the customers. To keep enough business activity lower margins are accepted. Expectations for resident and office constructions remain positive, although the effects of the credit crisis will have a effect on the demand.
Ballast Nedam presented lower results and lower margins in the first half year of 2008, facing similar problems. Infrastructure improved slightly however construction and development declined. The

[10] CBS, “Omzetgroei grootbedrijf bouw sterk toegenomen in 2007”, 14-4-2008, Webmagazine
[11] Rabobank, “Rabobank cijfers en trends”, juli 2008
[12] “Minder nieuwe kantoren”, 7-10-2008, NEPROM, retrieved 14-10-2008
[13] “Problemen in bouwsector door kredietcrisis”, 26-09-2008, Z24, retrieved 14-10-2008

market for construction is slowing down due to higher prices and less demand. However the number of PPP projects compensate for this decline. A large majority of the profit is from developing activities. Ballast Nedam therefore focuses more on developing activities. The company tries to offer a broad solution and integrates forward and backwards to be able to give an integrated solution. The infrastructure shows lower margins as well. Increased prices and prices of subcontractors put pressure on the margins. Profits are only made in niche markets.

For engineering services the market seems to be still growing. All segments are expected to grow since the demand for advice on energy, environment and transport stays high, according to Arcadis. The real estate sector seem to be affected by the financial problems, however services for infrastructure and other domains seem to grow. Grontmij also reports an increase in result and operating margin.

The movements in margins, noticed in previous sections are expected to continue according to the financial reports. Margins for engineering services, project development and operation seem to be increasing. More pressure is expected on the margins for construction and infrastructure. More forward and backward integration of construction companies is expected.
The initiation of new projects by project developers appears to largely depend on the effects of the credit crisis. However the demand side of the construction market seems to be relatively unaffected for now. Financing of new project initiations in the Netherlands is difficult due to lack of available money and not by the quality of the projects. Financial institutions in the Netherlands still finance project with high quality and very stable cash flows to finance[14] [11].

13.6. Market risk assessment using CAPM-beta

The last characteristic of the steps of the value chain is the market risk related to the steps of the value chain. The operational risk depends on the activities each company pursues. However the dependency of the company on the overall economic situation can be investigated over the value chain. This dependency on the market situation is called the market risk and can be measured by the parameter beta from the CAPM model.

According to the CAPM-model, higher profitability rates are related to the risk on the investment. The beta parameter of a company shows what the market risk of a company is. A higher market risk, means a higher beta which means higher volatility in the returns. If the overall market portfolio goes up, the stock is expected to profit from this situation with an amplification factor beta. If the beta is between 0 and 1 this means that the company faces a lower market risk than the overall market portfolio. If the beta is negative it means the company works counter cyclical. If the stock market goes up, the expected return of a company goes down.
The total risk of the return of a company consists of market risk and diversifiable risk. The diversifiable risk is the risk that is inherent to the decision and corporate governance each individual company takes. This risk is therefore for each company different. The market risk depends on the global economic situation. The beta can be defined as the linear regression coefficient between the historical market portfolio returns and the historical returns from the considered stock. The beta values in this study are retrieved from the financial database Thomson One banker, Datastream and Worldscope. The figures and course of the stocks over the last three years is presented in appendix XVIII.

The determination of the beta has some implicit considerations and limitations, next to the discussions on the CAPM-model itself:

[14] "INg wil welectiever omgaan met Nederlands vastgoed", 18-8-2008, nu.nl, retrieved 14-10-2008

- The determination of a company's beta requires data on the volatility of the returns of a company. This can only be done for assets listen on the stock exchange. Since companies listed on the stock exchange are generally active with multiple activities, determining a beta for each activity is hard.
- Only a limited number of companies have a listing on a stock exchange. Because of this fact the number of companies that possibly can be investigated is too low to statically draw correct conclusions. However the beta can give some insight in the ranges of market risk of the different activities.
- Discussion exists on the application of the CAPM model on real estate funds. The CAPM-model measures the companies return relative to the market return. Risk of inflation and interest rates are therefore not included in the CAPM. For general companies this limitation is acceptable. However for real estate developers one of the largest risks is the change of interest rates and inflation.
- The project development & investment funds considered get their income from both development activities and from exploitation and investment in existing real estate. For companies only focusing on development activities the beta will be higher due to the higher risk involved. However, companies having a similar distribution in their portfolio between new development and investment in existing real estate, the beta are expected to be comparable.
- The presented beta's give insight into the relative relation of the values. The values are not absolute sector values.

In Table 20 the betas of civil engineering companies that are listed on the Amsterdam stock exchange are listed. In Figure 74 the averaged and weighted averaged (on revenues) are shown.

Engineering services stocks	
Company	Beta*
	36 months
Fugro	1,15
Grontmij	0,91
Arcadis	0,77
Oranjewoud	0,61

Project Development & investment funds	
Company	Beta*
	36 months
Wereldhave	0,56
Unibail Rodamco	0,47
Corio	0,34
Eurocommercial Properties	0,23

Overall Construction stocks	
Company	Beta*
	36 months
BAM Group	1,41
Royal Boskalis	1,18
Heijmans**	0,98
Ballast Nedam**	1,06

Table 20 Beta-values for civil engineering related companies
*** source: Thomson ONE banker; datastream**
**** source: Thomson ONE banker; worldscope**

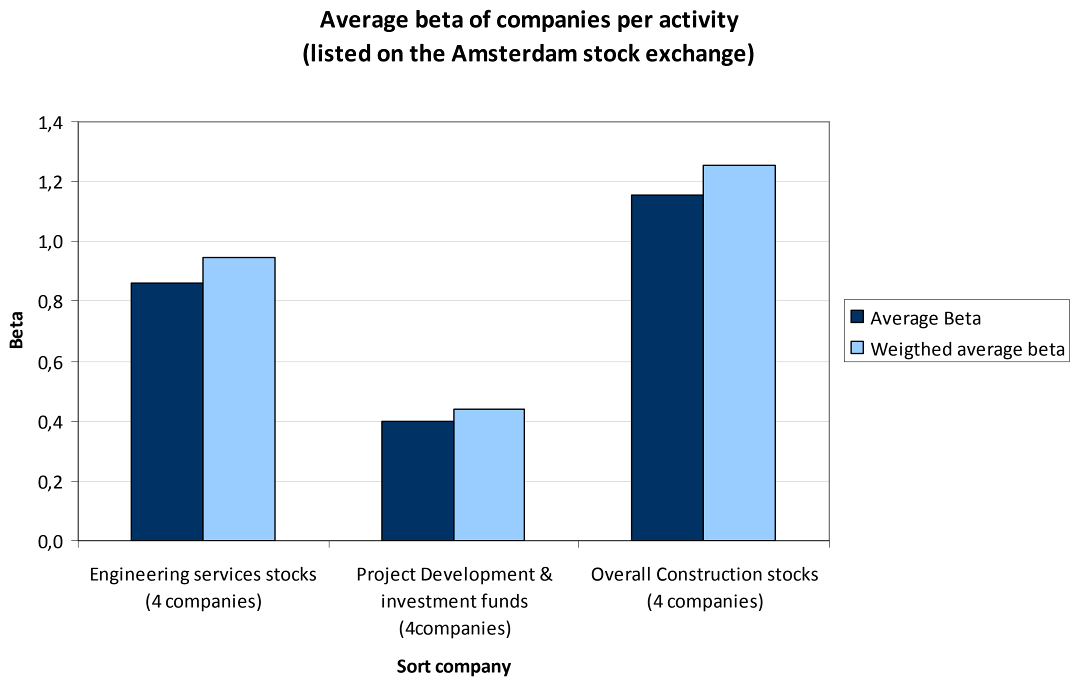


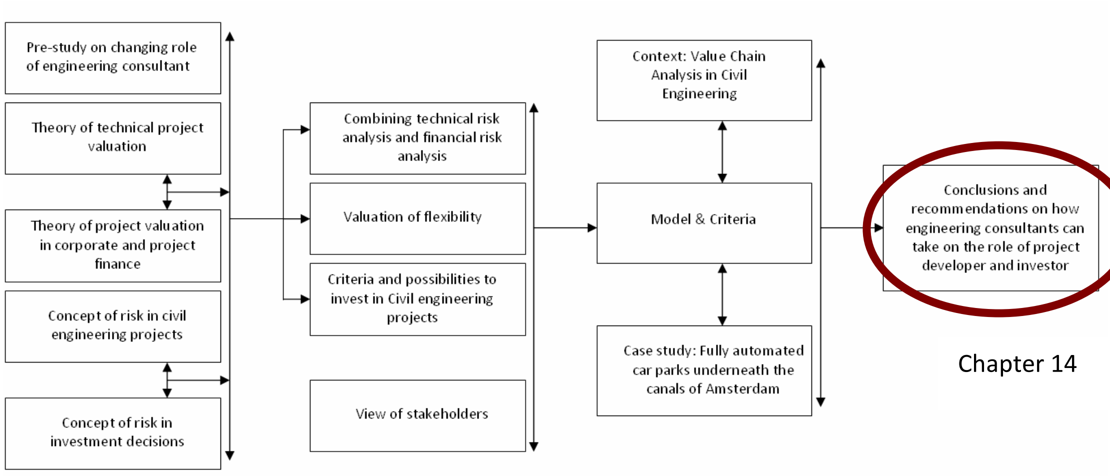
Figure 74 Averaged and weighted averaged (company revenues) beta's for companies in the civil engineering value chain

From the results above can be seen that:

- Engineering services have a market risk between the market risk that construction companies face and real estate investment funds face.
- Both engineering services and real estate development and investment have an average beta value of below 1, meaning that the market risk is lower than the market portfolio (AEX-index).

In this chapter…
In order to assess the possibilities for an engineering consultant as project developer and investor, the value chain of a civil engineering project should be analyzed. This analysis of the value chain of a civil engineering project is used as a context for this thesis. Each activity which is represented in a civil engineering project and thus in a Design, Build, Finance, Maintenance and Operate (DBFMO) project is considered separately by investigating the companies active in that step.
From the results can be seen that engineering consultants and project developers have the highest EBT-margins in the value chain of civil engineering. Project developers have the highest EBT-margins. Over the last three years the margins for the engineering consultants and project developers increased The margins on the activities construction and infrastructure have decreased and are the lowest in the value chain. Project developers have the highest value added per employee. The value added per employee of engineering consultants and project developer has increased for the last three years.
An engineering consultant has to focus on the project areas in which the technical expertise is the highest. In these areas the operational risks can be estimated best.
Construction companies have the highest beta parameter. The beta parameter of the CAPM shows the exposure to market risk. Project developers and investors have the lowest beta. Engineering consultants are in between. However the risk of interest rate changes is not included in the beta. However changes in the interest rate are large risks for project developers.

PART V: CONCLUSIONS AND RECOMMENDATIONS



14. CONCLUSIONS AND RECOMMENDATIONS

14.1. Introduction

This chapter discusses the conclusions, recommendations and considerations of this research. These conclusions are discussed following the list of research questions listed in chapter 3. The findings presented in this chapter are based on the literature study and the case study of the fully automatic car parks underneath the canals in Amsterdam.

In section 14.2 the answers on the research questions are discussed with the conclusions and recommendations. The conclusions and recommendations are in the grey boxes. The next section (section 14.3) gives a short summary of the most important conclusions of the report. Section 14.4 provides some recommendations for further studies. The chapter is concluded in section 14.5 with some discussion giving some considerations on the conclusions and recommendations.

The goal of the research, as described in chapter 3, is to investigate how engineering consultants can take on a more active role in projects as project developers and investors. This is done by:

- Investigating in what way technical risk in civil engineering can be translated optimally into financial risk through studying currently used project valuation methods in both civil engineering and corporate/project finance and adding to these techniques an analysis of the valuation of flexibility.
- Determining critical factors that influence the profitability and successful investment in projects.

From this research goal, research questions are formulated, presented in section 3.4. The conclusions presented in this chapter are descriptions of and answers to the research questions. This chapter follows the same order as the questions.

Q1. How are projects valued from a technical and from a financial point of view? How is uncertainty valued?

Q2. Which risks are perceived from the technical and which from the financial side of a project? Which factors and risks influence the value from the two points of views? How do the risks from both sides relate to each other?

Q3. What is the role of project flexibility in the valuation? How can it influence the financing structure?

Q4. What are the criteria and possibilities to invest and develop in civil engineering projects?

In this thesis the questions are discussed in two parts. The first part of the thesis discusses the theory. The central part of the research is the development of the model. In the model both the technical side of the project and the financial side are combined in the valuation. To this is the valuation of flexibility is added. Using this model to run Monte Carlo analyses can result into insight of the uncertainties and risks of projects.

14.2. Summary and conclusions

14.2.1. Conclusions on project valuation

In the late 1990s the traditional way of tendering large civil engineering projects was replaced by a new innovative contract. In the traditional way of tendering the responsibility of the initiating and the execution of a project rested with the public sector. The new way of tendering and the forming of Public Private Partnerships shifted the responsibility for the finance, maintenance and operation to the private sector. The shift in responsibilities caused the introduction of a new approach to the valuation of civil engineering projects.

1. The traditional way of tendering caused technical project valuations to focus mainly on investment costs. Financial project valuation took all the cash flows over the project life into consideration. The technical project valuation was taken as input for the financial project valuation. The technical side of the project valuation covered the construction costs and uncertainty in this phase. The financial side of the valuation focuses on the valuation of exploitation, financing and maintenance.

> To research the possibilities of developing of and investing in civil engineering projects the conventional cost estimations should be extended with the financial side of the project. This is done in the valuation model developed for this research.

2. In the project valuation uncertainty is included in multiple ways. Uncertainty in design parameters can be taken into account by a probabilistic approach. Technical risks are included in the project valuation as a cost post. The costs are assessed either as percentage of initial construction costs or by estimating the probability of occurrence and the consequence of the risk. In the model the technical approach to risk and uncertainty is included.

> Uncertainty in technical project valuation is taken into account by probabilistic cost estimation and risk analysis. Technical uncertainty results in risk reservations and a spread in the investment costs.
> Uncertainty in financial project valuation is based on the CAPM-model. Financial uncertainty is reflected in financing structure, interest rates and spread in operational cash flow.
> These valuations of uncertainty are included in the model.

3. In chapter 4 NPV methods are discussed. It is discussed in this section that standard NPV methods have limitations towards uncertainty and flexibility. Extended NPV methods can be useful in civil engineering due to the long project durations, the technical complexity and the influence of project's boundary conditions. From the literature study follows that standard NPV methods can be extended by taking flexibility into account. A method to include flexibility in the NPV is with the real options approach.

> Extended NPV methods can be useful in civil engineering in order to be able to take flexibility into account in the valuation. Including flexibility in the valuation methods in civil engineering is useful because of the long project durations, the technical complexity and the large influence of project's boundary conditions.

4. In financial project valuation timing of expenditures and phasing of the project can affect the feasibility. With detailed insight in the construction and the technical risks, the financial feasibility

can be optimized. Opportunities can be identified and profitability can be improved by considering the technical and the financial side jointly over the project duration

> Opportunities can be identified and profitability can be improved by considering the technical and the financial side of a project jointly over the project duration. This is needed because both sides influence the feasibility of a project and have interaction with each other.

14.2.2 Conclusions on technical risk and financial risk

Attractiveness to develop and to invest in a project, is to a large extent influenced by the investment risk. The investment risk is the risk that the project turns out to not to be as profitable for the investor as anticipated. The investment risk can be divided into the technical risk on the one side, and financial risk on the other side. Financial risks are all the risks that can influence financial parameters.

1. The Basel II accords of 2004 gave an overview of financial risk for banking institutions. This categorization can be applied on financial risks in projects. The financial risk according to Basel II is divided into: credit risk, operational risk and market risk. For civil engineering projects market risk and operational risk are the most important risks. Credit risk is in civil engineering projects of less importance. In this categorization the technical risk is included in the operational risk. Risk in all financial parameters is included in the market risk.

> In civil engineering projects operational risk and market risk are the most important risks. Market risk in civil engineering covers the external financial risks, such as interest rates and rates of inflation. In the operational risk the technical risk and financial risk related to the operation, are included.

2. In civil engineering projects both the operational risk and market risk are relatively low in comparison to other industries. civil engineering projects are characterized by long project durations, relative predictable and constant demand for the function it provides and relative low operational expenditures. The effect of market risk or operational risk on the project's profitability depends on the relative size of both effects and negotiations of the contracts with third parties. For infrastructure and large constructions the risk of fluctuating revenues is relatively small and in large projects often taken over by the government. This results in a lower market risk in comparison to the operational risk. If the revenues in the exploitation phase have a larger impact on the project's feasibility, which is the case with more market oriented functions, the market risk is higher relative to operational risk.

   The financial risk perceived by financers is described by the financing structure and the interest rates. The financing structure is determined by the overall project risk. The riskier the project is expected to be, the more equity is required in the project. The interest rate consists of a risk free interest rate and an additional interest rate compensating for the risk that is faced by that specific portion of debt (SWAP).

> In civil engineering projects the most important market risks are:
> - Changes in interest rates (taken by bank)
> - Changes in inflation

The financial risk related to the operation includes financial risks in the exploitation and of financing. Financing risk in project finance in civil engineering focuses on:

- The risk of insolvency of the financing reservation
- The risk of insolvency of the debt service

3. In the practice of project financing of civil engineering projects the risk of changing interest rates is taken by the bank. Important financial risks are the financing risks as described above. The risk of insolvency can be assessed by analyzing the financing reservation. Important in the management of the risk of insolvency of the debt service are three ratios determining the risk of insolvency of the debt service.

The risk of insolvency of the debt service in project finance is determined by three ratios:

- Debt Service Cover Ratio
- Loan Life Cover Ratio
- Project Life Cover Ratio

These ratios are included in the model.

3. The amount of financial risk in comparison to technical risk depends on the market orientation. If operating cash flows are expected to be more stable, financial and market risk are less important. Technical risk is more important in this case. For example in large infrastructural works in which demand is relatively stable or predetermined, technical operational risk dominates over financial and market risk. In cases where the cash flows in exploitation phase shows larger volatility, the importance of financial risks increases over technical risks. If exploitation is included in the project, market risk and financial risk is larger.

In the case study of the car park the spread due to the financial risk to the total risk is larger than the contributions of the market risk and the technical risks. The contribution of the market risk to the total risk is larger than the contribution of the technical risk in the case study.

14.2.3. Conclusions on valuation of flexibility

In section 13.1 it is concluded that considering extended NPV methods can be advisable due to the nature of civil engineering projects. Long project durations, technical complexity and the influence of changing boundary conditions cause large uncertainties in projects. Over the project life this can result in new relevant information or a new playing field of the project. The valuation of flexibility is studied in this thesis by considering two methods of valuation of flexibility

- Valuation of flexibility with real options
- Valuation of flexibility when individual risks cancel out

Real option valuation in civil engineering can be a useful addition on standard project valuation. Valuation of real options should be introduced in the valuation of civil engineering projects since it has significant value.

The method is useful because it:

- forces the identification of future decision points
- identifies, values and maps project scenarios
- facilitates possibilities to anticipate on changing project boundary conditions in the future and take advantage of opportunities that may arise from these changes

Valuation of flexibility when individual risks cancel out can improve the profitability by:

- shifting risks in timing
- shifting risks to third parties

The practical application of valuation of flexibility is largely influenced by the layout of civil engineering projects. In the two interviews in chapter 9 the practicality of valuation of flexibility was discussed qualitatively. From these interviews followed that the legal setup of projects and incentives implied by payment structures influence the possibility of successful application of flexibility.

Although the value of flexibility is recognized by the actors, the application of flexible thinking is limited by the legal setup of projects and the incentive implied by the paying structure. A change in these characteristics is needed before option thinking can be applied on a large scale.

In the literature study three methods for valuation of real options are described:

- Black-Scholes model
- Decision tree and Influence diagrams
- Binomial or multinomial tree

From this study follows

1. The Black-Sholes was developed initially for the valuation of financial options. The model however can not be applied on real options. The underlying assumptions which hold for financial options do not hold for real options in civil engineering. However the Black-Sholes model can be used as a useful thinking model to identify and analyze options in civil engineering. It can help identify the key-levers of real options.

The Black-Sholes model can not be applied for real options. The underlying assumptions which hold for financial options do not hold for real options in civil engineering. However the Black-Sholes model can help to identify and analyze options in civil engineering

2. From both literature study and an application to the case study it was shown that decision tree analysis is a useful addition to conventional project valuation in civil engineering. By applying decision tree analysis in project valuations the project course is made graphically visible and future decision points have to be identified. Future scenarios are clearly identified based on prior decisions and path dependencies

Decision tree analysis can be applied well in project valuation in civil engineering. This method is useful when path dependencies are important. This method forces to map decision points in the project's course graphically.

3. From both literature study and an application to the case study, it was shown that binomial tree method is not very applicable for civil engineering projects. The method neglects path dependencies and aggregates all possible project outcomes. The importance of proceeding to a next phase in a project is dominant over the path and decisions leading there. A binomial or multinomial tree is therefore generally applied to projects where the phasing of the project is more important than the path dependencies. Valuation with a binomial tree can be useful for projects which are determined by a sequence of external uncertainties. This can be the case for inventorying a portfolio of projects in different phases of development.

Binomial tree is less useful for civil engineering practice. This is due to the fact that civil engineering projects show less clear phasing, external uncertainty about continuing the project to the next phase is not common and path dependencies in civil engineering are important.

14.2.4. Conclusions on criteria and possibilities of development and investment

Criteria and possibilities for an engineering consultant to develop and invest in projects in the field of engineering can be divided in three focus points:

General conclusions

The strategic challenges and opportunities for an engineering consultant to take a more active role as project developer and investor follow from previous studies and are described in chapter 3. Most important opportunities are:

- The product an engineering consultancy delivers, gains credibility if it is participating in the risk.
- By acting as investor profit can be made on attractive investments by commercialization of present expertise and contacts
- Possibilities are opened to proactively push projects on the market. Based on technological insight of projects and know-how of technological innovations, market feasibility can be investigated.
- Additional value and challenges are created for employees. Next to thinking from a different perspective and expansion of commercial knowledge engineering consultants can benefit from innovative and profitable solutions.

1. In order to see if the forward integration on the value chain can lead to better business, the value chain of civil engineering projects is discussed in chapter 13. This study can show in which phase knowledge can be commercialized best. The earnings before tax margin shows what profit is made per Euro turnover. From the analysis of 32 companies in different parts of the value chain of civil engineering was found that project development yields the highest margins on turnover and on value added.

Engineering consultancies and project developers have the highest EBT-margins in the value chain of civil engineering. Project developers have higher margins than engineering consultancies.

Over the last three years the margins for engineering consultancies and project developers increased. The margins for the rest of the value chain decreased. For construction the margin has been below 1% for the last two years. This movement is expected to continue in the near future.

2. In this study the value added per employee was investigated in order to judge where a company can optimally utilize its resources. This value added is the sum of the operational costs and profit of a company. The value added results from the use of the factors of production labor, capital and land. The value added divided by the number of employees generating this value added, results in the value added per employee. It shows how much an employee can add to the value chain.

Project developers have the highest value added per employee in the value chain of civil engineering. The value added per employee of engineering consultants and project developers has increased over the last three years.

3. For an engineering consultancy, like Royal Haskoning, the technical expertise lies in the fields of transport, utility construction and maritime. From internal studies follows that in these fields the highest margins are made. Having the highest margins shows that the knowledge is most valuable. In these sectors the expertise can be commercialized best.

An engineering consultant has to focus on the project areas in which the technical expertise is highest. In these areas the operational risks can be estimated best. For Royal Haskoning this expertise lies in water domain, utility construction and especially in transport and traffic.

4. Important for investing in projects is the setup of a business case in which the technical and financial side of a project is combined. The cash flows depend largely on the type of project which requires for each sort of project to model the cash flows separately.

For the research of a project's feasibility and profitability a financial model should be developed in which the technical and financial sides are combined; such a model is developed for car parks in this study. The uniqueness of the cash flows of each sort of civil engineering project and contracts require specific models to be setup for each project sort and cash flow structure.

4. For a project's profitability the structure of the cash flow in exploitation phase is important. For an engineering consultant the competency is the technical knowledge. For successful investing in a civil engineering project relative stable cash flows is attractive. In this case the investing risks lies in the construction phase in which the engineering consultant has its expertise. The engineering consultant can estimate the spread due to the technical risk best and should commercialize that knowledge.

Projects with stable of fixed commercial cash flows are attractive to invest in for an engineering consultant. In these projects the investment risks mainly consists of technical risk which is the competency of the engineering consultant.

Conclusions on developing and investing in car parks

In the case study the criteria and possibilities of developing of and investing in fully automated car parks underneath the canals in Amsterdam is investigated for Royal Haskoning. To asses the attractiveness to develop and invest in fully automated car parks a model is developed. In this model operational, technical and financial parameters of the project are combined to asses the project. In chapter 10 the project is described. The data from this study is inputted in the model resulting in the output results presented in chapter 11. Based on the assumptions listed in the appendix the following conclusions can be drawn.

1. The NPV of an investment in this case is expected to be positive in the base case described in chapter 11. In this base case the car park's exploitation is 30 years and is leveraged with 70% debt. In this case a WACC of 8,5% is taken which is according to the risk involved with the project. The NPV is expected to be positive for a 76% percent interval. The effect of the cash flow resulting from selling the construction at the end of the lifetime is not taken into account in the case study. This can have an effect on the NPV of several hundreds of k€. Also reducing the spread of the NPv can reduce the probability of a negative NPV.

> Investing in fully automated car parks underneath the canals in Amsterdam is expected to be profitable. The NPV (WACC= 8,5%) is expected to have a positive value with a probability of around 76%. This probability could be increased by reducing the largest risks. The value at the end of the lifetime is not taken into account. Investing in the car park can be an interesting investment.

2. The mean expected internal rate of return gives the expected return rate on equity. From the results appears the car park to have a mean expected internal rate of return of around 11,1 %.

> The internal rate of return of investing in fully automated car parks underneath the canals in Amsterdam is expected to have a mean value of 11,1%. The IRR its 95% exceeding interval is around an IRR of 5%. Investing in the car parks can be an interesting investment.

3. The most important design decision is the number of floors of the car park .Due to geotechnical problems, expected problems with ground water flows and strutting, the construction of a 4 storey car park is expected to cost over € 5 Mio extra than the 3 storey car park. This includes an average addition risk reserve of € 2,4 Mio for geotechnical problems during construction. However the expected revenues of the extra parking spaces over the exploitation phase result in a larger IRR.

> A 4 storey car park has a higher NPV than a 3 storey car park. The construction costs of a 4 storey car park are significantly higher due to geotechnical risk, more expensive construction and larger costs of the building pit. However the NPV of the additional parking spaces cover the increased cost increase

4. From the sensitivity analysis of the car park the influence of parameter's uncertainty on the NPV can be studied by determining the regression coefficients. From this analysis follows that a standard deviations change in the occupation rates has the highest influence on the NPV. Second is the rate of inflation followed by the parking fare.

From the sensitivity analysis follows that variations of the occupation rates, rate of inflation and parking fare have the largest influence on the NPV. A reduction of the standard deviations of these parameters has the largest impact in order to reduce the spread of the results.

5. Since there is little experience with people parking in fully automated car parks, alternative exploitation scenarios have been studied. One possibility is to exploit the underground construction as a self storage business. Using decision tree analysis, the value of switching to alternative exploitation, was investigated. After two years of exploitation a decision point was identified on which switching to a self storage business was possible. It was calculated that the option of switching has significant positive NPV. For the mean value the option of switching has a extra NPV of € 1,3 Mio, in which the costs of switching are included.

The option of developing a car park including the flexibility to switch to alternative exploitation as self storage space has significant value.

6. In Amsterdam multiple locations have been identified for possible development of car parks underneath the canals. The effect of developing multiple car parks is studied using real option theory. In these cases it is assumed that the second car park is exact the same as the first one. No effects of experience or learning are taken into account. Two cases have been studied:
   - The case that tendering is early, if no exclusive right for development can be obtained
   - The case that engineering can start after exploitation, if an exclusive right for development can be obtained.

   Both cases show that the option of developing a second car park, given the success of the first, has significant value. If engineering is done early, the value of the option lies in shifting the left tail to the more profitable region. If an exclusive right can be obtained and engineering can be postponed the mean value of the option can be up to 1.000k€.

The option of developing a second car park, if an exclusive option on developing the second car park is obtained, has significant value. The option of starting the development of the car park after the start of exploitation of the first car park has the highest value.

7. Variations in the financing structure have a large impact on the NPV of the project. In chapter 11 these effects are described quantitatively. The largest impacts have the parameters of using debt financing and the percentage of debt used in the project. Optimization of these parameters in the negotiation can result in an increase of the IRR of several percent. The optimization of the financing reservation, shifting of risk reserves to later phases, periodic payments of interest, interest rates and the value of the construction at the end of the lifetime has significant impact.

The financing structure has large impact on the profitability of the project. In optimizing the financing structure and considering financing costs, large savings and higher profits can be made. These opportunities lie in combining technical insight and financial knowledge.

14.3 Summary of conclusions

To research the possibilities of developing of and investing in civil engineering projects the conventional cost estimations should be extended with the financial side of the project. Since financial and market parameters influence the feasibility to a large extent (see Figure 2), opportunities can be identified by considering these parameters jointly with the technical parameters.
Real option valuation in civil engineering can be a useful addition on standard project valuation. This valuation method forces the identification of future decision points, values and maps project scenarios and facilitates possibilities to anticipate on changing project boundary conditions. Flexibility in a project's course, has significant value (see Figure 3), for example by identifying back-up scenarios. The real option valuation method that can be applied best is the valuation using decision trees. This method graphs possible project's courses and takes path dependency into account. The Black-Scholes model, which is used for the valuation of financial options, can not be applied for the valuation of real options. The underlying assumptions of the model do not hold for real options.
Engineering consultants can extent their activities as project developer and investor. Engineering consultants have expertise in assessing technical risk. They should focus on projects in which technical risk dominates. This can be done by focusing on projects with stable cash flows in the operational phase or forming alliances with market parties taking on the market and financial risk in the operational phase. Engineering consultants should focus on a sort of project in which they have a competitive advantage over other engineering consultants or in a market where there are few competitors. An indicator of these two aspects is the EBT-margin.
From the financial figures over the period 2005-2007 can be seen that engineering consultants and project developers have the highest margins. Over this period a movement is visible that these margins increased. The value added per employee is for the activity project development higher than of the engineering consultant.

In the case study presented in this thesis, the possibilities of developing of and investing in a fully automated car park are investigated. The 3 storey car park is located in Amsterdam in the city part Oud-Zuid underneath the Boerenwetering. The case study is studied using a financial model in which the technical project aspects are combined with the financial aspects. Based on the results from a Monte Carlo simulation the feasibility and sensitivity of the project can be assessed.
The 3 storey car park has a length of 263 m and a width of 13,6 m. The foundation of the car park is 9m underneath the bottom of the canal, which lies at 3,4m – NAP. In the car park 460 fully automated parking spaces will be realized, of which 75% will be used for short term parking and 25% for licensed parking. The parking fare for short term parking in this part of Amsterdam is 3,80 €/h. The determined average occupation rate of the short term parking spaces is 35%. The licenses offered are a full license, night license and office license costing respectively €2500, €1200 and €1800 per year.
The development of the car park is an interesting investment opportunity. The construction costs will add up to approximately 33,7 Mio € and the construction has an expected duration of 157 weeks. With the simulation a Net Present Value of the project of 5.010 k€ is obtained. In the model a Weighted Average Cost of Capital (WACC) of 8,5% is used. The probability of a positive NPV is 76%. The internal rate of return (IRR) is on average 11,1%. The 95% exceeding level is an IRR of 5%. The IRR of a 4 storey car park is 11,6% and therefore expected to be more profitable. The options of changing exploitation and developing a second similar car park have significant value.

14.4. Recommendations for further activities and research

In this section some recommendations for further research activities are listed.

Develop one integrated valuation model for some typical civil engineering projects. For this the different technical aspects of the projects require studying as well as the incentives and payment structures. This way the profitability of different sort of projects can quickly be assessed.

More research needs to be done on the case specific input. The design can be detailed further and the technical and financial assumptions need to be researched further to make a good assessment of the attractiveness to develop the fully automated car park. Also a more extensive risk analysis should be done.

Study on the management criteria of repositioning in the value chain is needed. In this study the valuation and business economics side was central. In order to make a good decision on whether engineering consultants could integrate forwards also legal, human resource and cultural aspects should be considered.

To asses it competitive strength and the market characteristics in that field of expertise the market conditions should be assessed categorized by type of project. PPP-projects differ too much from standard real estate development to draw generally holding conclusions.

In the last month of this research the global financial situation changed enormously. The effects of this on project finance in civil engineering slowly get visible: Some projects are cancelled, interest rates, and with that WACCs, are rising and financing for projects is harder to obtain. The effect of the credit crisis is needed to study in order to be able to determine the strategy for engineering consultants.

14.5. Practical recommendations & discussion

14.5.1. Considerations for Royal Haskoning

Royal Haskoning has technical expertise which it could commercialize by participating with risk in projects of which they do the engineering. The question whether Royal Haskoning should set up an investment fund was left outside the scope of this study. In order to answer this question well, a number of other aspects need to be considered. The research on these other aspects requires different expertise and access to more data. This was not present during this study.

This study focused on three practical aspects of the question whether there are possibilities for Royal Haskoning to take a more active role as project developer and investor:

- Setting up a financial model to value the attractiveness to develop and invest in a civil engineering project
- Researching the positioning in the value chain
- Asses the attractiveness of developing and investing in fully automated car parks underneath the canals in Amsterdam

However, outside these aspects more aspects should be taken into account. These aspects can have a significant impact on the investments feasibility, but are outside the scope of this thesis.

14.5.2. General consideration

In the civil engineering market a lot of forward and backward integration could be seen over the last years. Construction companies start to focus on facility management on one end of the value chain and on project development and investment on the other hand. Ballast Nedam Concessions, Heijmans @Venture and BAM PPP are examples of these integrations. Also project developers see potential in developing real estate outside the conventional commercial real estate. For example OVG started a division for infrastructure development. Engineering consultancies start to focus more on integrated solutions and taking advantage of their own expertise. Arcadis and DHV have own investment funds. Grontmij supplies advice in the field of asset management and project management. In this light the market in civil engineering and for engineering consultants seems to direct towards supplying solutions over multiple steps of the value chain.

Public private partnerships are interesting projects to invest in due to the stable cash flows in the exploitation phase and the low market risk. Since for large infrastructural works the exploitation risk is taken over by the government, the uncertainty in the cash flows during the exploitation phase is reduced significantly. This results in projects which are interesting to invest in for parties being able to asses the technical risk well.

Doing business as a project developer instead of an engineering consultant requires different skills, a different mindset and culture. Next to technical expertise, employees of the project development department should also create expertise in the financial and entrepreneurial field. In this case Royal Haskoning has to compete for human resources in a different market with different market conditions. This could influence remuneration or working conditions. The study whether there is potential inside Royal Haskoning or whether it can be attracted from outside, is outside the scope of this research.

An important assumption underlying on the decision to consider repositioning in the value chain, is that the factors of production, needed in the new position, are available. In the previous paragraph the redevelopment of labor skills was central. Next to this it is assumed that enough capital can be raised to finance the participation. Project Developer use a lot of capital during operation. The availability and the form this capital is organized should be considered.

Another important characteristic which should be taken into account in the capability to carry the development costs. Especially PPP-tenders have large investment costs without any certainty of winning of the tender. If repositioning is considered, enough financial means should be available to finance the upfront costs in lost tenders.

14.5.3.Consideration on fully automated car parks

In the research of Boschloo ([6], 2001) was stated that the risk of winning and losing a tendering should not be omitted. For this project the risk of not acquiring a project should be emphasized. However the overview from a portfolio perspective on being an investor was outside the scope of this research. Therefore this risk was not included in the study. However, in the decision tree analysis the probability of winning the tender was included as a post memento.

By reducing uncertainty in the input parameters the distribution of the NPV and IRR can be narrowed down, which could lead to a more interesting investment opportunity. In the base case the NPV has a 76% probability to be positive. The uncertainty in the input parameters can be reduced in three ways:

- More research on the distribution of the input parameters. Additional research could lead to more insight in the uncertainty of a parameter and possibly reduce the assumed standard deviation.
- Measures to reduce the uncertainty. By taking measures a one time cost could be made in order to reduce the assumed standard deviation. A trade needs to be made between the one time costs of reducing the uncertainty versus the effect on the outcome. This can be done comparing the costs of the measure with the effects using the regression coefficients determined in this study (see section 11.4).

- Negotiating of risk. If an uncertainty is taken by a third party this will lead to a reduction of the risk of an investor. The parameters which formerly was assumed to have a distribution, is then transformed to a fixed input parameter.

The influence of the car park policy of the city of Amsterdam can be large. The policy that the city wants to replace parking spaces on ground level with places underneath the canals is taken as an initial value for the project. However, if the city of Amsterdam changes this policy and the parking spaces are an addition to the current number of parking spaces, this will influence the occupation rates. This will have a large effect on the return on the investment in the car park.
The exact financing structure could not be determined in this case study, since this depends on the market situation and negotiations with financial institutions. Therefore this study is limited to showing the influence of the financing structure and use of only equity and debt. In reality different repayment schedules and a variation of financial component with different institutions are imaginable. This financial engineering takes place together with financial institutions and was outside the scope of this study. Also additional financing and subsidiaries by the city of Amsterdam are not taken into account.

Another psychological risk that should be taken into account is the risk of poor success with open user groups. The limited experience that is present in the Netherlands with fully automated car parks is only with closed user groups, who:

- Received training in the use of the parking system
- Are known by the system. With this experience knowledge the system can optimize the intake and output of the system.

The effects of using these systems for short term parking and therefore with open user groups are unknown and should be studied. In open user groups training is not possible and optimization through learning by the system is not possible.

Developing multiple car parks will also contribute in other benefits from learning. Experience in the development in car parks in general can lead to more orders, which might increase future expected earnings as well. These effects are not included in the study but can be significant.
In the case study in this thesis, some important assumptions were made which should be fulfilled in order that the results will hold. If a 4 storey car park will be constructed the number of entrances should be increased from 7 to 9. Whether this is technical feasible is not researched in this study. Next to this the increase in strutting and sheet piling is not considered in detail in this study. The increases taken into account in the study are estimations.

14.5.4. General applicability of the model

The structure of the valuation model developed in this study can be used for the valuation of different projects in civil engineering. The groups of stakeholders and the cash flows in each civil engineering project are similar. The relation of the stakeholders which each other and the structure of the cash flows is the base of the valuation model. In each civil engineering project where the structure generates revenues over time the structure of the model could be applied.
However, contracts and market orientation vary very much over the projects. The project specific payment structure in the exploitation phase and specific input require adjustments to the model. Each civil engineering project has distinctive characteristics which influence the input. For example, the payment structure of a car park differs from the fixed payment structure for large infrastructural works. So the structure is applicable to more civil engineering projects, however variations in the payment structure may require model adjustments.
The identification of real options in a project requires technical insight and depends on path dependencies. The modeling of decision trees needs to be redone for each project. Real options in the project's course are project specific.

14.5.5. Global financial situation

In 2007 problems on the financial markets in the United States surfaced. The risks in projects were structurally assessed too low causing many situations of insolvency. By a domino effect soon the global financial situation worsened. Due to heavy financial problems in the United States the global financial economy slowed down. The effect on the real economy was until now limited. At the end of September 2008 the global financial situation again worsened rapidly. Stock exchanges plummeted which caused a large financial crisis. This time the real economy seems to be affected and a recession seems unavoidable.

Question is how the financial crisis will influence investment decisions in the civil engineering world. Financing is in civil engineering an important aspect due to the large up front costs. The financing is affected in two ways by the financial crisis:

- Increased interest rates in project finance due to lack of available credit
- Different attitude towards risk

The availability of credits for project financed projects has dropped dramatically in the last year. In the period until September 2008 interest rates had increased 1 – 1,5 % for project finance. Expectantly, the interest rate on project financed projects will have increased even further due to the recent events. In the model the first 1,5% was taken into account in the WACC.
Next to this available credit is granted under different conditions as before. Financial institutions have become a different perception and attitude towards risk. A more risk avers attitude with the financial institutions is seen. Credit is granted less easily until the financial institutions have more confidence in the global economy and their own financial position.

These two effects cause the development of and investment in commercial real estate and infrastructure to slow down. However, as was discussed in section 13.5, a selection of projects on quality will expectably take place. Financial institutions are still willing to invest in high quality project with stable cash flows. High quality projects will generate enough cash flows to cover the debt service and will have a low risk profile.
Second consideration is that investing in (high quality) real estate and infrastructure can be an interesting investment in financial heavy weather. Due to large fluctuation of value papers, investing in fixed assets can provide a relative safe and stable investment. In economic downtimes investments in construction and infrastructure are attractive due to low market risk. By investing in infrastructure and utility building the government can cause an economy stimulating effect.

Projects with relative low risk and expected stable cash flows, it is still interesting to invest in, despite the financial situation. The car park considered in this study will have a relative low market risk profile because of two reasons:

- Parking situation in Amsterdam is very tense
- The need for parking spaces is relatively independent from the market situation (inelastic demand). People still need parking spaces although the economy might be in downtimes.

From these two facts can be concluded that the car park is expected to face relative low market risk. The high and stable (not declining) parking fares cause the cash flows to expectedly be stable. So although the financial situation is disadvantageous, an investment in fully automated car parks could be interesting, however the terms of financing could be poorer than a couple of years before. The possibilities of developing and investing in fully automated car parks largely depend on the negotiations and risk profile of the financial institutions on that moment.

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LIST OF ABBREVIATIONS

ADCSR	Annual Debt Service Cover Ratio
APT	Arbitrage Pricing Theory
BTA	Binomial Tree Analysis
CAPEX	Capital Expenditures
CAPM	Capital Asset Pricing Model
DB	Design and Build
DBFMO	Design, Build, Finance, Maintenance and Operate
DCF	Discounted Cash Flow
DCSR	Debt Service Cover Ration
DTA	Decision Tree Analysis
EBT	Earnings Before Tax or Profit before tax
EBIT	Earnings Before Interest and Taxes
EBITA	Earnings Before Interest Taxes and Amortization or Operational Profit
EBITDA	Earnings Before Interest Taxes Depreciation and Amortization
FCF	Free Cash Flow
IRR	Internal Rate of Return
ITS	Interest Tax Shield
LLCR	Loan Life Cover Ratio
NAP	Normaal Amsterdams Peil (Normal Amsterdam Level)
NOI	Net Operating Income
NPV	Net Present Value
OCF	Operating Cash Flow
OPEX	Operational Expenditures
PLCR	Project Life Cover Ratio
PPC	Public Private Comparator
PPP	Public Private Partnerships
PSC	Public Sector Comparator
ROA	Real Option Analysis
ROIC	Return On Invested Capital
SPV	Special Purpose Vehicle
SPC	Special Purpose Company
VaR	Value at Risk
WACC	Weighted Average Cost of Capital
WC	Working Capital

APPENDICES

APPENDIX I – PARKING SUPPLY AND DEMAND

I.1. Parking supply, demand and policy

The market situation for parking spaces has a large effect on the feasibility of developing a fully automated car park. The market side consists of three factors in the near region surrounding the car park influencing the exploitation of the car park.

- Parking space supply
- Parking space demand
- Parking policy

To research the profitability of developing and investing in a fully automated car park the parking situation should be investigated. Using the insight into the parking situation is needed to determine the occupation rate which is feasible for the fully automated car park underneath the Boerenwetering. The parking policy is left outside the scope of this study.

These three factors determine the parking situation in a given research area. The parking supply is given by the existing parking spaces and the planned parking spaces in the area to be considered. The demand for parking spaces depends on a large number of parameters:

- Urbanization of the location (available alternatives for transport)
- Reachableness of considered area from outside
- Number of functions available in considered area
- Parking habitudes of the people parking in the considered area
- Possibilities of double use of parking spaces

The parking policy of a city influences the parking situation to a large extent. The policy can both affect the supply or the demand in a certain area. The policy of a city towards parking can influence the standards which are used to calculate the demand. Or it can increase or reduce the supply available in a certain area. As is described in [72],[73] parking policy includes:

- Vision on parking
- Targets which are pursued
- Stating boundary conditions and initial values for the parking situation
- Stating actions which are needed to reach the targets

In determining the need for parking spaces the parking balance should be determined. In the parking balance the supply and demand of parking spaces are evaluated, given the current parking policy. The need for the new development of parking spaces then follows from the parking (in)balance in the influence area of the new car park. The supply can be determined by making an inventory of the characteristics of the influence area of the car park. The demand is calculated using the steps described by the CROW ([72]). The parking policy is assumed to stay constant from the situation as it is now.

I.2. Parking supply around the Boerenwetering

The parking supply in the region is given by the total available parking spaces in a considered area. The boundaries are determined by the acceptable walking distances as listed above (see Table 7). The influence area of the parking for the function living is shown in Figure 75. In this area there are currently 1120 parking spaces available.

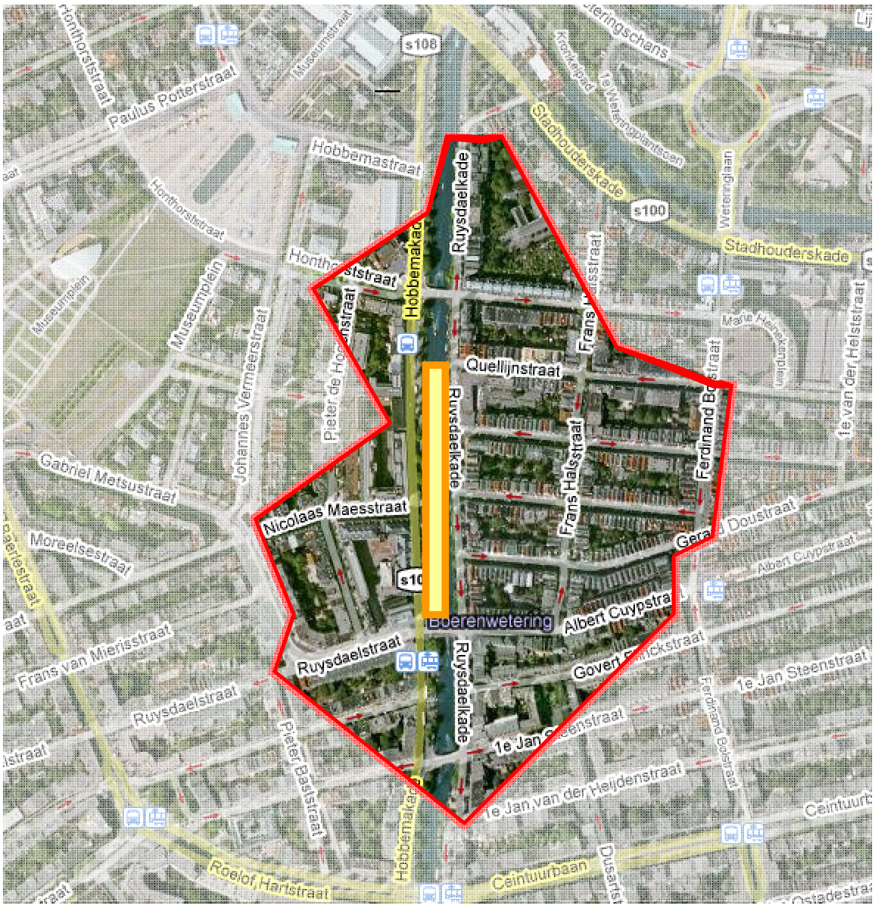


Figure 75 Influence area (200 m) for the function living

For the functions shopping and working the influence area stretches up to 500 m walking. In Figure 76 the influence area for shopping and working is shown. In this area the car park Heineken plein is located (right "P"). The car park Museumplein (left "P") is located just outside the influence area. In Table 21 the key characteristics for these car parks are given. This area largely coincides with the division as made by the parking department of the city of Amsterdam (see Figure 77). In this area there are approximately 2900 parking spaces[15].

Car Park	Capacity	Fare	Open	License cost
Q-Park Museumplein	600	€3,80 per hour	7h – 1h	€ 4740 per year (full 24h/7) € 3324 per year (office times) € 1700 per year (nights only)
Heinekenplein	256	€ 2,50 per hour	7h30 – 2h Sun. closed	

Table 21 Car parks near the Boerenwetering

15 Handcount and parking numbers by city of Amsterdam (2006, [24])

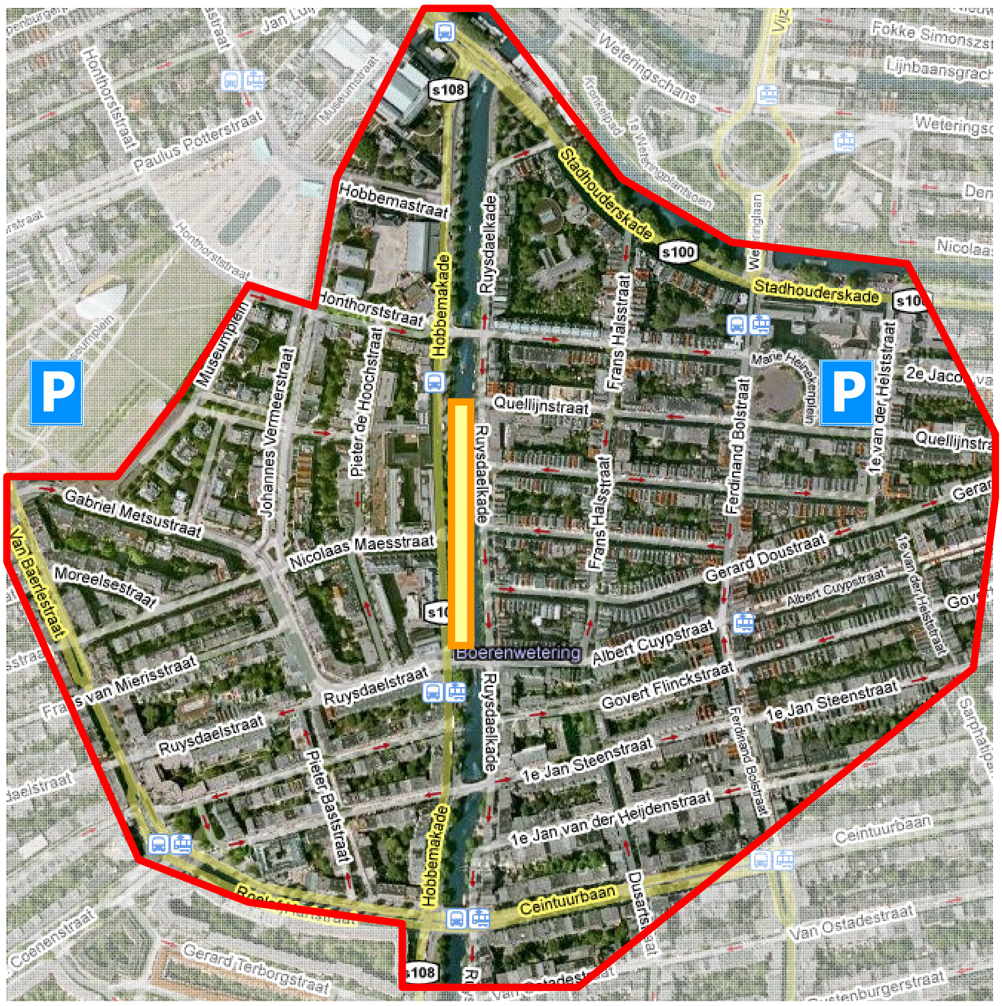


Figure 76 Influence area (500 m) for the function shopping and working with car park Museumplein and car park Heinekenplein

I.3. Parking pressure

The current parking situation can be given by the parking pressure. The parking pressure is the average number of cars parked as a percentage of the total normal available parking spaces (excl special parking spaces, reserved spaces for emergency services etc.). The current parking pressure in the areas influenced by a car park underneath the Boerenwetering is shown in Figure 77 (City of Amsterdam, 2006,[24]). These areas have a maximum walking distance to an entrance of the car park of 400 – 500 m.

Area	Parking capacity
3 – Frans Hals neighborhood	678
4 – Hercules Seghers neighborhood	307
13 – Johannes Vermeer neighborhood	805
20 – Duivelseiland	371

Table 22 Parking capacity around car park Boerenwetering [24]

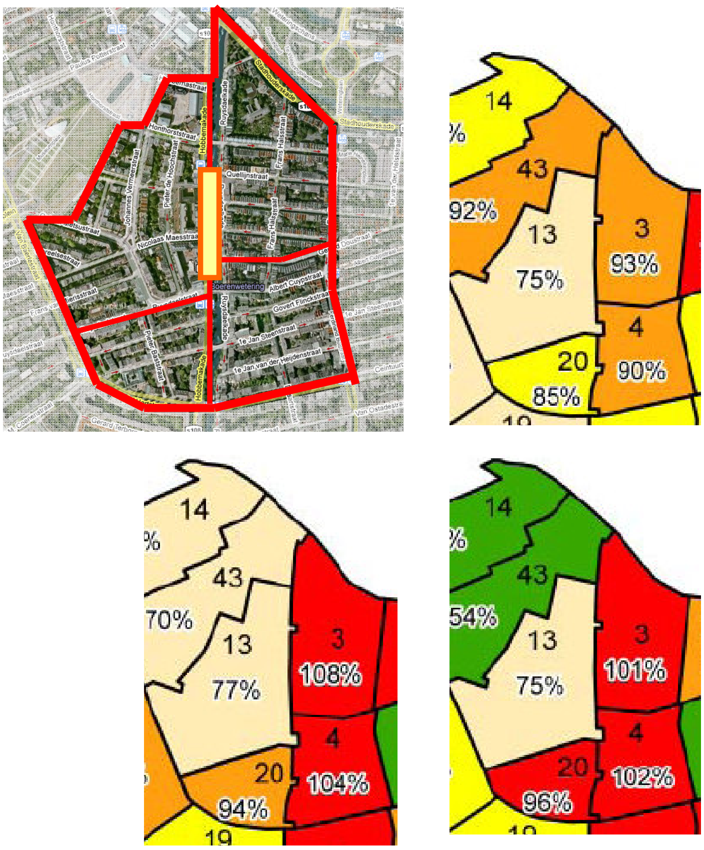


Figure 77 Parking pressure around the Boerenwetering[24][23]
Left top. Location of area's and location of car park (orange-yellow)
Right top. Parking pressure during the day
Left bottom. Parking pressure in the evening
Right bottom. Parking pressure in the night

I.4. Parking demand around the Boerenwetering

For the parking balance the demand for each function needs to be calculated. This calculation is done primarily using the guidelines en experience numbers described by CROW (2003, [72]).
The demand for parking spaces for the function living determined based on the number of cars owned by the residents in that area. The number of cars is a multiplication of the number of houses and the number of cars per house.

The number of households inside the influence area can be estimated using the numbers from the city of Amsterdam (2002, [23] & 2008, [25]) on the number of houses. In the influence area not much variation and no tall buildings over five storeys exist. Based on this, the number of houses is assumed to be spread homogeneously over each neighborhood. The number of houses inside the influence is calculated by taking the area percentage of the number of houses per neighborhood (see Table 23)

	Number of houses	% of neighborhood inside influence area	
Frans Hals neighborhood	1653	70%	1160
Hercules seghers neighborhood	1606	40%	640
Johannes Vermeer neighborhood	705	30%	210
Duivelseiland	853	20%	170
Total			**2180**

Table 23 Calculation of the number of houses in the influence area (function: living)

The number of parking spaces needed per house can be done in two ways. The first calculation focuses on the number of cars owned per house. In 2002 the city of Amsterdam reported that in the total city of Amsterdam the number of cars owned per household was around 0,63[16]. This number in 2002 was 0,4[17] in the area around the Boerenwetering. From the updated numbers by the city of Amsterdam (2008, [25]) follows that this number is expected to have grown, because of great popularity if the neighborhood among young starters and other groups owning a car. Next to this the function living requires some parking spaces for visitors. For city area's values are given from 0,1-0,2 parking spaces per house.

Experience numbers from CROW on the other hand, show values for rental houses of 0,2-0,6 cars per house and for bought houses (expensive class) in the range of 1,3-1,5 cars per house. These values include parking spaces reserved for visitors. In this neighborhood around 20% are bought houses and 80% is rental houses. This would result in:

$$80\% * 0{,}4 + 20\% * 1{,}4 = 0{,}6 \text{ cars per house}$$

If for the number of cars per house a value 0,5 is taken, this results in a demand of 1090 parking spaces.

For other functions the similar approach is used.. In Table 25 the presence of other functions is listed (city of Amsterdam (2008, [25] & 2002, [23])). In Table 25 the numbers in the two influence area of the car park Boarenwetering are given. For the 200m influence area the same percentages are used as in Table 23. For the area outside these regions estimations are made.

	# of shops	# of people working	# of pubs & restaurants
Frans Hals neighborhood	35	785	30
Hercules seghers neighborhood	53	526	31
Johannes Vermeer neighborhood	15	1680	12
Duivelseiland	28	1680	13

Table 24 Number of shops, employees and pubs& restaurants around the Boerenwetering

	# in 200 m area	# in 500 m area
Shops	56	150
People working	1500	4500
Pubs & Restaurants	40	95

Table 25 Presence of functions around the Boerenwetering

The CROW gives number of parking spaces per 100 m2 of a function.

	Parking spaces per 100m2	Average space per # of a function
Shops	2,5-3,5	100 m2 per shop
Working	0,8-1,3	35 m2 per employee
Pubs & Restaurants	4 - 10	100 m2 per pub/restaurant

Table 26 Number of parking spaces per function

[16],10, 11 City of Amsterdam, 2002, [22]

[17] City of Amsterdam, 2002, [22]

If the demanded parking spaces for these functions are added, the parking demand is retrieved. For the ranges in parking spaces per 100m2, the highest value is taken. In Table 27 the demanded parking spaces per function are given.

	200m influence area	500 m influence area
Living	1090	-
Shopping	196	525
Working	650	1950
Pubs & Restaurant	400	950
Total (single use)	**2336**	
Supply parking spaces	**1120**	**2900**

Table 27 Demanded parking spaces per function

I.5. Double use of parking spaces

As described by the CROW ([72]) double use of parking spaces is possible and should be taken into account. The demand for parking spaces per function varies over the course of the day. This way a parking space needed for offices during the day, can be used by residents for overnight parking. This will reduce the theoretical total demanded parking spaces.

Function	Working day Overday	Afternoon	Night	Shopping evening	Saturday afternoon	Night	Sunday afternoon
Living (#)	50	60	100	90	60	60	70
Shopping (#)	30	70	20	100	100	0	0
Working (#)	100	100	5	10	5	0	0
Pubs& Restaurants (#)	30	40	90	85 - 95	70 - 75	100	40 -45

Table 28 Presence percentages per function per timeframe [72]

Function	Working day Overday	Afternoon	Night	Shopping evening	Saturday afternoon	Night	Sunday afternoon
Living	545	654	1090	981	654	654	763
Shopping	59	137	39	196	196	0	0
Working	650	650	33	65	33	0	0
Pubs& Restaurants	120	160	360	360	300	400	180
Total	**1374**	**1601**	**1522**	**1602**	**1183**	**1054**	**943**

Table 29 Demanded parking spaces for an influence are of 200m around car park Boerenwetering

From Table 29 can be seen that the maximum demand is around 1600 parking spaces on an workday afternoon and on a shopping night. If the parking supply of 1120 parking spaces in the same area is considered, one can see that only Saturday night and Sunday afternoon sufficient spaces are available. In the above table only the influence area at a distance of 200m from the Boerenwetering is calculated. However for the functions shopping and working a larger group of people would consider parking at the Boerenwetering location. In the table below all the parking space demand is given in an area of 500 m around the Boerenwetering. These totals can not be compared with the 2900 parking spaces present in this area. This is due to the fact that the parking spaces for the people living in a range from 200 m – 500 m from the Boerenwetering are not taken into account. However without the demand of these residents the demanded parking spaces already exceed the supply of parking spaces..

Function	Working day Overday	Afternoon	Night	Shopping evening	Saturday afternoon	Night	Sunday afternoon
Living (#)	545	654	1090	981	654	654	763
Shopping (#)	157	367	105	525	525	0	0
Working (#)	1950	1950	98	195	195	0	0
Pubs& Restaurants (#)	285	380	855	855	712	950	427
Total	**2937**	**3351**	**2150**	**2586**	**2086**	**1604**	**1190**

Table 30 Demanded parking spaces for an influence area of 500 m for the functions shopping, working and pubs & restaurants

In the current plans the city of Amsterdam wants the car park to replace parking spaces on ground level. The amount of parking spaces on the Ruysdaelkade and in the Frans Halsstraat will be reduced in order to improve the quality of the street. In all cases the entrances of the car park will replace the parking spaces on one side of the Ruysdaelkade. Even if the car park would create additional parking spaces to the current existing spaces, the demanded number of parking spaces would exceed the available parking spaces. In the plans of the city of Amsterdam the demand would exceed the supply with an even larger amount.

APPENDIX II – OCCUPATION RATE

II.1. Determination of the average occupation rate

An important parameter in the feasibility study of a car park is the occupation rate. In the model the input parameter occupation rate is an average value of the occupation rates over a long period (> year). In the model the average occupation rate over a week is taken as average long term occupation rate. Doing this seasonality in the occupation rate is neglected. In the car park two different groups of users are identified.

- Licensed parkers, generally for functions working and living
- Short term parking, for the functions of shopping and pubs & restaurants.

II.2. Determination ratio licenses: short term parking

The ratio between licensed parking and short term parking is an important factor in the feasibility calculations. Short term parking is more profitable. However the cash flows have a higher risk due to larger volatility. Short term parking takes place during the day. On the other hand is licensed parking less profitable and cash flows less volatile. Long term parking for the function living generally takes place between 18h and 8h and for about half during the day (see Table 28). Office licenses run generally from 8h until 18h, complimentary on the living licenses. By varying the ratio of licensed parking spaces : short term parking spaces the risk-profile can be altered. The more licensed places, the lower the risk and the lower the expected return.

In appendix III the demanded number of parking spaces was determined for the location of the Boerenwetering. In the policy of the city of Amsterdam the car park is mainly intended as replacement for residents parking their car on ground level. The functions living and working prefer licensed parking spaces. For the functions visiting, shopping and pubs & restaurants short term parking spaces are needed.

Function	Work day Morning	Afternoon	Night	Shopping night	Saturday afternoon	Night	Sunday afternoon
Living +working (#)	2386 (81%)	2473 (74%)	1406 (65%)	1372 (53%)	718 (34%)	523 (33%)	610 (51%)
Visiting, shopping, Pubs& Restaurants (#)	551 (19%)	878 (26%)	1178 (35%)	1576 (47%)	1368 (66%)	1081 (67%)	580 (49%)
Total (#)	**2937**	**3351**	**2150**	**2586**	**2086**	**1604**	**1190**

Table 31 Parking space demand in cars at the Boerenwetering

Since the demand for short term parking exceeds the supply around the Boerenwetering and the city of Amsterdam want to reduce the number of parking spaces on ground level, a high number of short term parking is attractive in order to maximize the profit. The high demand for parking spaces will cause the volatility of the occupation rate to stay relatively low while making larger returns than with licensing. In feasibility studies by the city of Amsterdam (2004, [21]) a ratio for licensed parking spaces to short term parking spaces of 20% : 80% is given. Because the high demand for living and working, in this study a ratio of 25%:75% is assumed.

	Licensed parking	Short term parking	Total
3 storeys	116	348	464

4 storeys	146	439	585

Table 32 Division of parking spaces in licensed spaces and short term parking spaces

II.3. Occupation rates

The occupation rates for licensed users and for short term users differ both in absolute value and in timing. If the occupation of each user group at each time of the day over a week is estimated, the occupation rate of the car park can be determined and optimized. In hours where licensed parking demand is high, a larger number of license places could be reserved. When licensed parking demand is low, relatively more short term parking spaces could be reserved.

The presence percentages of CROW publication 182 (1003, [72]) can be used for the determination of the occupation rates for licensed parking. Like described in the previous section the percentages for the function living and working are attractive for licensed parking.

Function	Workin day Overday	Working day Afternoon	Working day Night	Shopping evening	Saterday afternoon	Saterday Night	Sunday
Living (%)	50	60	100	90	60	60	70
Working (%)	100	100	5	10	5	0	0

Table 33 Occupation rates of licensed parking

As can be seen in Figure 78, the average occupation rate for short term parking is mainly determined by the length of the peak and by the occupation at night. In the afternoon and especially on weekend days the short term parking spaces are nearly all occupied (see Figure 79). To optimize the parking revenues short term and licensed parking at night could increase revenues.

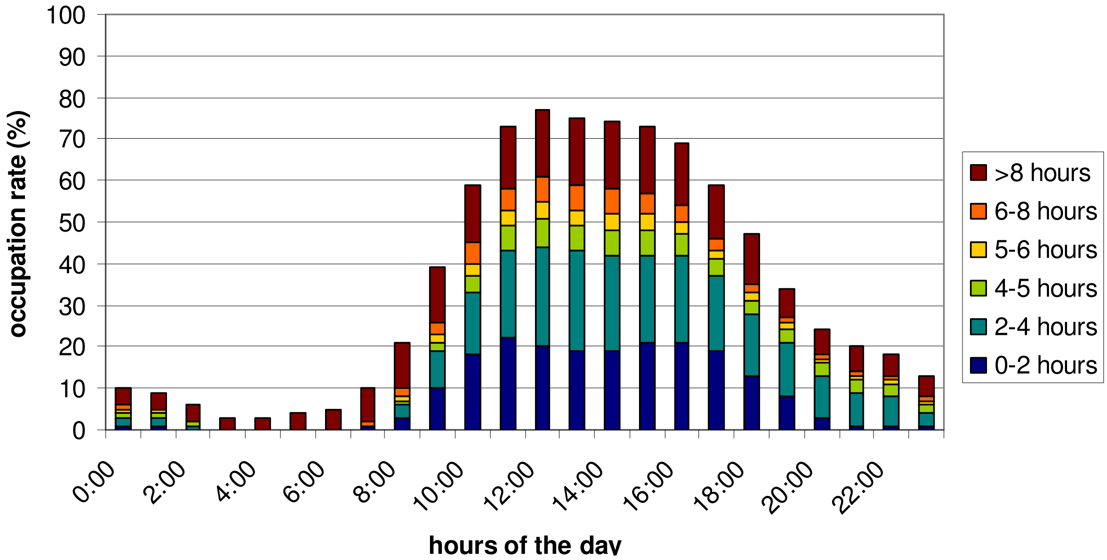


Figure 78 Average hourly occupation rate per hour on working day for non-license holder. Average of 6 car parks in city centers in Dutch cities [5]

	0-2 hours	2-4 hours	4-5 hours	5-6 hours	6-8 hours	>8 hours (μ=10h)
Visitors (% of total visitors)	60,5 %	23,9 %	4,5 %	2,2 %	2,3 %	6,6 %

Table 34 Distribution of visitors by parking duration

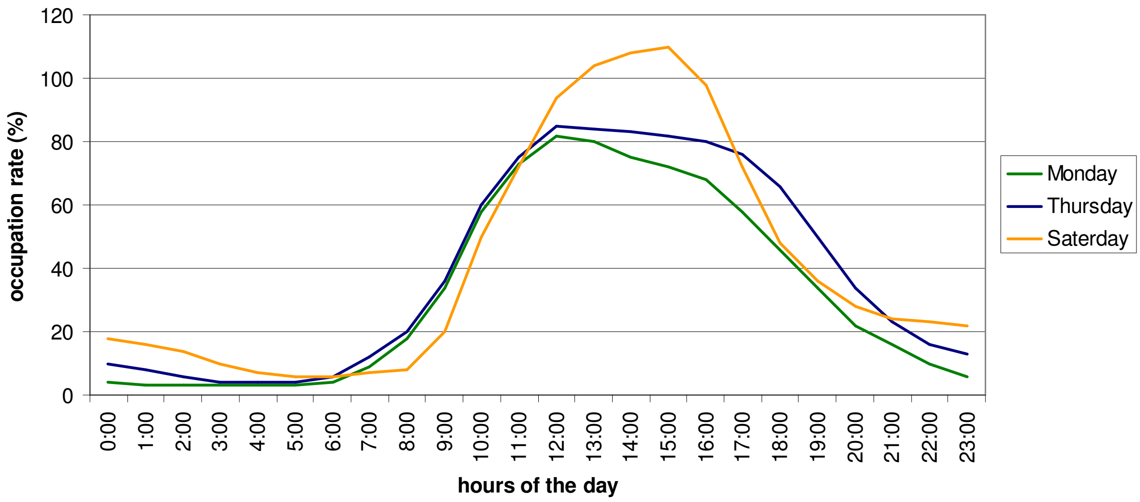


Figure 79 Hourly occupation per day of the week for non-license holders. Average of 6 car parks in city centers in Dutch cities [5]

From the data in Figure 78, Figure 79 and Table 34 average occupation rates for short term parking can be determined.

Average occupation rate monday:	32,6%
Average occupation rate thursday	39, 0%
Average occupation rate saturday	41,0%
Average occupation rate per working day	34,4 %
Average duration of short term stay in car park	2,5 hours

Table 35 Average occupation rates short term parking

II.4. Double use with license differentiation

Revenues of licensed parking spaces can be optimized by introducing different license sorts. If for example in a 3 storey car park 125 licenses would be sold to residents living there, not all 125 reserved parking spaces would be occupied. From Table 28 follows that only 60% of the residents require their parking space over day. In order to optimize revenues, different licenses should be considered to use this opportunity of double use of a parking space.

In this study three licenses are considered focusing on the different user groups. As described the function living and working are attractive for licensed parking. In the function living users can be identified who need a parking space the whole day and users who need it only when they return from work and in the weekends. However, selling extra night licenses will reduce the number of available parking spaces in the weekend, which are highly profitable.
In Table 21 license prices of the Museumplein car park are given. In the feasibility study of the city of Amsterdam a value for a full year license a price of € 1800 euros per year is given (2004, [21]). For the optimization the license prices in Table 36 are used.

Full License	24 h per day, 7 days per week	€ 2500 per year
Office License	8h – 18h on work days	€ 1800 per year
Resident license (nights)	18h – 8h on all nights	€ 1200 per year

Table 36 Licenses and prices

The effects on the revenue by selling different licenses are researched using three cases. For revenue optimization short term parking generates the highest amount of revenues. However this increases the exploitation risk. As a basic assumption for the cases is that purely the revenues from the licenses is considered. Parking spaces not occupied by license holder on a certain time of the day are not taken into the evaluation. For the revenues of the total car park, these free parking spaces are considered. The three cases are:

- Case 1. Only full licenses
- Case 2. Full licenses and office licenses only. Spaces of full license holders that are not occupied during the day are sold as office licenses. Residents can only buy a full license. Spaces that are not occupied at night can be sold as short term parking.
- Case 3. Full licenses, office licenses and resident license for night parking only. The full licenses and night licenses for residents are sold according to the presence percentages as listed in Table 28 (60% of all resident licenses are full licenses and 40% of resident licenses are night licenses). This way licenses are offered based on the demand by the residents around the Boerenwetering. The parking spaces available during the day are sold as office licenses.

	3 storeys; 116 licensed parking spaces
Case 1	116 full licenses Revenue € 290.000,-
Case 2	116 full licenses 46 Office Licenses Revenue € 372.800,-
Case 3	70 full licenses 46 Office licenses 46 resident licenses Revenue €313.000,-
Case 3 optimal revenue	116 office licenses 116 resident licenses Revenue €348.000,-

Table 37 Cases of license optimization

From Table 37 follows that license optimization leads to a significant improve in revenue. The most profitable case would be if only full licenses and office licenses would be sold. If the parking situation is such that people are willing to buy a full license, although they won't use it during the day, case 2 would be the most profitable, resulting in an increase in revenues of 28,8%. However since the license prices are considerably higher than licenses issued by the city of Amsterdam, the possibility of selling only full licenses is questionable. In this situation the distribution of licenses according to case 3 is more likely. In this case only the people present at home during the day are willing to buy the full license. In this case the supply of licenses is according to the demand in the area. This will lead to a increase in revenues of 8%.
Obviously from Table 36 follows that only selling office licenses and night licenses would generate more revenues than only full licenses. However, assumed is that a minimum full licenses should be offered in order to reduce the parking pressure in the neighborhood.

For the optimization of the licensed parking spaces, case 3 is taken for selling of licenses. For the feasibility study the offering of three licenses is considered, in a ration which reflects the demand in the area around the Boerenwetering. This would yield a 8% increase in revenues in comparison to selling only full time licenses. In the course of the exploitation however, this division should be altered to adjust the supply to the demand. In this way the selling potential is optimally used.

II.5. Overall occupation rate of the car park

Combining the occupation rates for license holders in Table 33 and the occupation rates for short term parking listed in Table 35, the overall occupation rates can be determined. For the optimization of the licensed parking spaces case 3 is assumed. In the case of 116 licensed parking spaces, there are 125*24h = 3000 parking space*hours (psh). For the short term parking this leads to 348 parking spaces * 24h = 9000 parking space*hours (psh). The parking space hours (psh) of the not occupied licensed parking spaces are added to the totals of the short term parking . This multiplied by the average daily occupation rate results in the occupation rate of alle short term parking spaces. the total occupation rate is calculated by combining the occupied license places and the occupied short term parking spaces. The expected overall car park occupation rate is 51,1%.

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Licensed places	2925 psh 97,5%	2925 psh 97,5%	2925 psh 97,5%	2925 psh 97,5%	2862 psh 95,4%	2275 psh 75,8%	2625 psh 87,5%
Residual licensed places	75 psh	75 psh	75 psh	75 psh	138 psh	725 psh	375 psh
Short term Parking	9000 psh	9000 psh	9000 psh	9000 psh	9000 psh	9000 psh	9000 psh
Average daily occupation rate	34,4%	34,4%	34,4%	34,4%	34,4%	41%	41%
Total occupation rate	**50,4%**	**50,4%**	**50,4%**	**50,4%**	**50,0%**	**52,2%**	**53,9%**

Table 38 Calculation total occupation rate of car park

In the model occupation rates for licensed parking and short term parking are kept apart. The residual parking of the non occupied licensed parking spaces (see Table 38) result in an overall additional 9,1 parking spaces for short term parking on average. Therefore in the model for a 464 parking spaces car park the next input is taken:

464 parking spaces
116 licensed parking spaces occupied by
- 70 full licenses
- 46 office licenses
- 46 resident night licenses

348 short term parking spaces
Average occupation rate of short term parking is 35%

APPENDIX III – CASE STUDY INPUT

This appendix covers the input of the model on the case study:

- Distribution of unit prices in cost estimation
- Distribution of planning
- Structure of soil

III.1. Cost estimation unit prices

* To Subcontractors	T-value	unit	5% value	95% value
Destruction quay	1.000	€/m	800	1.200
Insert sheet piling	1.150	€/ton	1.000	1.300
Struts	2.000	€/ton	1.500	2.500
Excavation of building pit	14	€/m^3	10	18
Soil improvement	21	€/m^3	18	25
Pouring underwater concrete	171	€/m^3	140	200
Pumping dry of building pit	75000	€/stuk	75.000	75.000
Placing of filter	11	€/m^2	11	11
Fundex piling	672	€/stuk	672	672
Pouring concrete floor	158	€/m^3	158	158
Pouring concrete outer walls	400	€/m^3	400	400
Other concrete inner walls	500	€/m^3	500	500
Pouring concrete roof	470	€/m^3	470	470
Pouring concrete entrances	500	€/m^3	500	500
Armoring	1200	€/ton	1.200	1.200
Other concrete	500	€/m^3	500	500
Placing canalplates middle floors	50	€/m^2	50	50
Brickworks	75	€/m^2	75	75
Pouring concrete quay	400	€/m^3	400	400
Other & destruction building pit	50.000	€/stuk	50.000	50.000
Soil replenishment	14	€/m^3	14	14
Engineering & Mobilisation	209.916	€/stuk	209.916	209.916
Fully automated Parking system	11.364	€/stuk	11.364	11.364
Installations (per 3 floors 1 piece)				
energy	130.500	€/stuk	130.500	130.500
power	26.000	€/stuk	26.000	26.000
light	43.800	€/stuk	43.800	43.800
communication	65.500	€/stuk	65.500	65.500
ventilation	100.000	€/stuk	100.000	100.000
water	15.000	€/stuk	15.000	15.000
fire prevention	6.000	€/stuk	6.000	6.000
security	10.000	€/stuk	10.000	10.000
Surroundings				
Trees	2.750	€/stuk	2.750	2.750
Cables and Pipes	300.000	€/stuk	300.000	300.000
Traffic measures	35.000	€/stuk	35.000	35.000
Monitoring quay	120.000	€/stuk	120.000	120.000
Soil curing	3.000.000	€/stuk	3.000.000	3.000.000
Other	220.000	€/stuk	220.000	220.000
* To Public Sector				

-				
* To Customer				
-				
* To Other				
Ongoing Capex	1	st	0	0,0

III.2. Planning

Activity	Comments	Start (week)	5 % (weeks)	Duration (weeks)	95 % (weeks)	End (week)
Engineering and mobilization		0	20	26 weeks	32	26
Destruction quay		26	2	4 weeks	8	30
Insert sheet piling		30	8	10 weeks	16	40
Struts		36	4	6 weeks	8	42
Excavation of building pit		42	16	20 weeks	32	62
Soil Improvement		62	3	4 weeks	6	66
Pouring underwater concrete		66	3	4 weeks	6	70
Pumping dry of building pit		70	3	4 weeks	8	74
Placing of filter		74	2	2 weeks	3	76
Fundex piling (5,9m long)		76	8	10 weeks	20	86
Pouring concrete floor		84	9	13 weeks	17	97
Pouring concrete outside walls	2 weeks after floors	86	9	13 weeks	17	99
Other concrete inner walls	2 weeks after walls	88	9	13 weeks	17	101
Placing canalplates middle floors	2 weeks after outer walls	88	9	13 weeks	17	101
Pouring concrete roof	2 weeks after inner walls	90	8	13 weeks	17	103
Pouring entrances		86		13 weeks		89
Armoring	During concrete works	84	19	19 weeks	19	103
Other concrete		106	2	4 weeks	6	110
Construction of brickworks		110	2	2 weeks	3	112
Construction concrete quay		110	4	6 weeks	8	116
Completion other/ destruction building pit		112	4	6 weeks	8	118
Soil replenishment		110	2	3 weeks	4	113
Installation fully automated parking places	4 weeks after start of installations	114	12	16 weeks	26	129
Installations		110	12	16 weeks	26	126
Trees		6	8	10 weeks	14	16
Cables and pipes		6	10	15 weeks	20	21
Traffic measures		6	121	123 weeks	124	122
Monitoring quay		13	9	9 weeks	9	21
Soil curing		42		24 weeks		66
Other		26	111	111 weeks	111	52
Licenses		0	20	26 weeks	36	
Total						129 weeks

Table 39 List of planning parameters

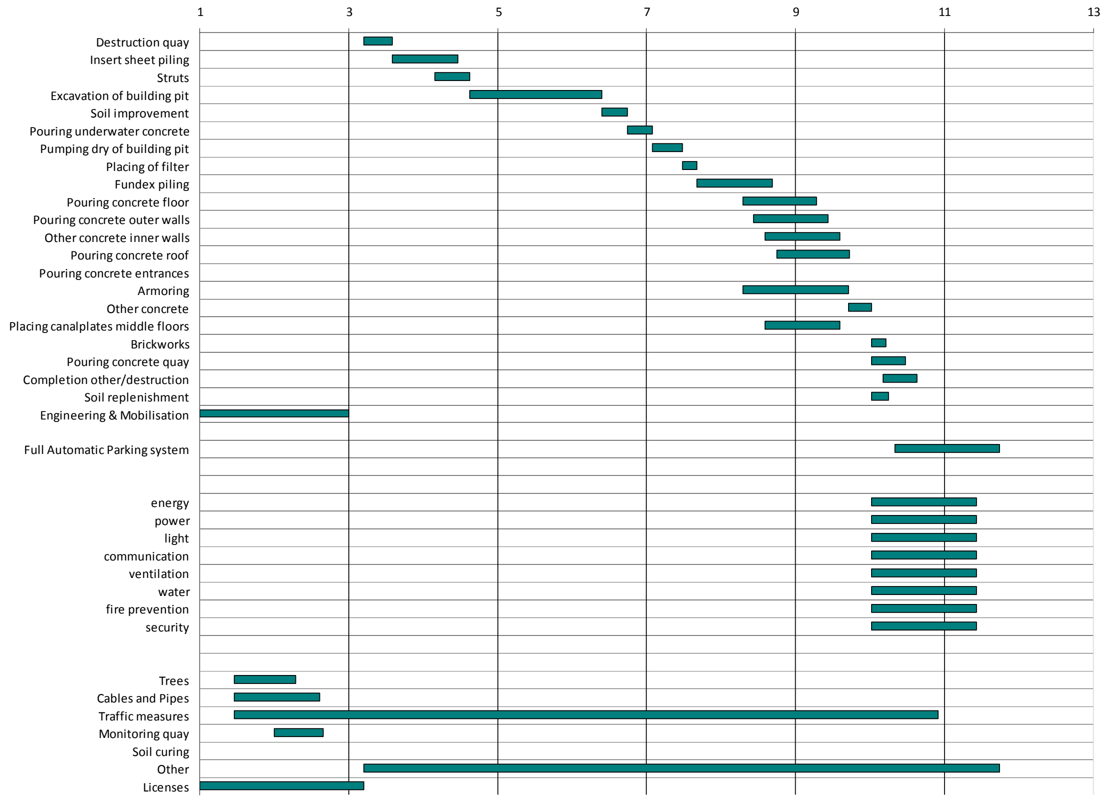


Figure 80 Gant chart of construction

III.3 Structure of soil

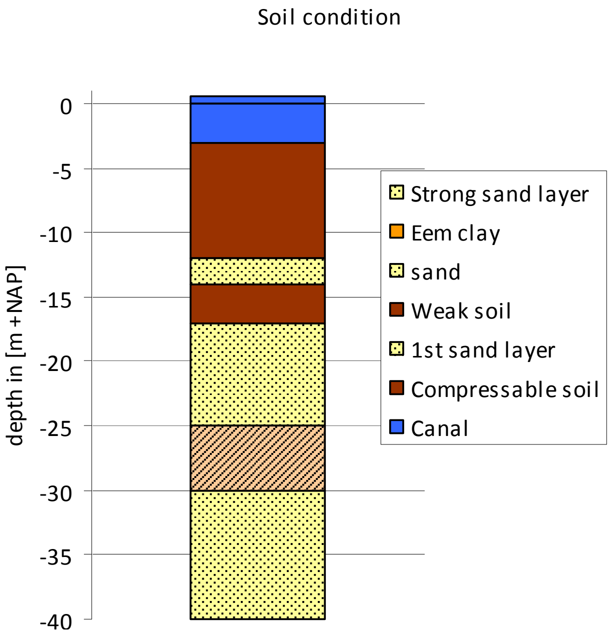


Figure 81 Structure of soil at Boerenwetering

APPENDIX IV – RISK ANALYSIS

For the parking garage a short risk analysis is performed. The quantified risks are included in the model and are part of the Monte-Carlo simulation. The Risman-classification is used for the risk management. In this study the risks are estimated using classifications given for probability, money consequences and time consequences. The classification quality, safety and neighborhood are not included in this comprehensive risk analysis.

For the probability of occurrence of the risks 5 categories are identified. For the calculation value a discrete distribution is used with a value p of occurrence.

Score	probability	Calculation value
1.	0 % - 1%, occurs seldom	0,005
2.	1 % - 5% unlikely	0,03
3.	5 % - 10 % probability exists, not big	0,075
4.	10 % - 25 % considerable chance	0,175
5.	25 % - 50 % very likely	0,375

Money consequences are focused on direct financial effect resulting from the unforeseen event.

Score	Money consequences	Calculation value
1.	€ 0 – € 25.000	€ 12.500
2.	€ 25.000 - € 50.000	€ 37.500
3.	€ 50.000- € 100.000	€ 75.000
4.	€ 100.000 - € 250.000	€ 175.000
5.	€ 250.000 - € 500.000	€ 375.000
6.	€ 500.000 - € 1.000.000	€ 750.000
7.	> € 1.000.000	€ 2.000.000

Time consequences focus on delays of the project because certain phases can not start or taking longer than anticipated. A week delay in the work is priced as the costs of having the construction site open one week including personnel and equipment. In this case this is estimated at € 50.000 per week.

Score	Time consequences	Calculation value
1.	1 week	€ 50.000
2.	2 weeks	€ 100.000
3.	2 weeks - 1 month	€ 200.000
4.	1 month – 4 months	€ 600.000
5.	> 4 months	€ 1.400.000

	Risk	Comment	Probability	Consequence	E[risk]	Timing
1.	Mistakes in design due to wrong assumptions	Construction and exploitation phase	25 % - 50 %	4 month delay + €500.000 - 1.000.000	€ 506.250	Week 26- Week 130
2.	People are reluctant to use the automatic system	Exploitation phase	10 % - 25 %	no delay >1.000.000	€ 350.000	Week 117-end
3.	Construction site can not be reached by city traffic or events	Construction phase	25 % - 50 %	1 month delay + €250.000-500.000	€ 215.625	Week 0 - Week 130
4.	Vibrations and other construction activities cause damage to buildings near construction site	Construction phase	10 % - 25 %	4 month delay €250.000 - 500.000	€ 170.625	Week 26 - Week 130
5.	Affected groundwater table causes damage to building near construction site (wooden piling)	Construction phase	10 % - 25 %	4 month delay €250.000 - 500.000	€ 170.625	Week 30 - Week 117
6.	Unexpected disadvantageous soil conditions	Construction phase	25 % - 50 %	2 weeks delay €100.000-€250.000	€ 103.125	Week 26 - Week 97
7.	Other licenses are not granted (fire, groundwater, cables)	Mobilisation phase	10 % - 25 %	2 weeks delay €250.000-500.000	€ 83.125	Week 0 - Week 26
8.	Parking system works improperly	Exploitation phase	5 % - 10 %	1 month delay €500.000-1,000.000	€ 71.250	Week 117 - end
9.	Construction license is not granted	Mobilisation phase	10 % - 25 %	1 month delay + €100.000-250.000	€ 65.625	Week 0 - Week 26
10.	Archeological discovery during excavation	Construction phase	5 % - 10 %	1 month delay €100.000-250.000	€ 28.125	Week 30 Week 66
Total					**€ 1.614.375**	

APPENDIX V – CASE STUDY INPUT

Project life		
start project		1-1-2009
duration of total project	yr	30,0
end of project		1-1-2039
max project duration	yr	40
start construction		1-1-2009
duration	quarters	11,7
end construction		1-12-2011
start exploitation		1-12-2011
duration of exploitation	yr	27,1
end of exploitation		1-1-2039

Parking Demand						
Number of spaces	#	500				
Avg space per parking space	m2	12				
parking spaces for license holders	%	25				
parking spaces for daily users	%	75				
Phasing of exploitation						
spaces available period 1	%	50				
spaces available period 2	%	75				
spaces available period 3	%	100				
Availability						
Availability in 1st year of exploitation	%	90				
Availability long term	%	98				
Occupation rate after start of exploitation						
	year	1	2	3	4	6-end
occupation rate	%	35,0	35,0	35,0	35,0	35,0
	V	0,214	0,214	0,214	0,214	0,214
	σ	7,5	7,5	7,5	7,5	7,5
	Distr.	N(35;7,5)	N(35;7,5)	N(35;7,5)	N(35;7,5)	N(35;7,5)
Parking fare				V	σ	Distribution
parking fare	€/hour	3,8		0,1	0,38	N(3,80;0,38)
annual increase	%	3				
				V	σ	
Full license		2500		0,1	250,00	N(2500;250)
Office license	per year	1800		0,1	180,00	N(1800;180)
Nightlicense		1200		0,1	120,00	N(1200;120)
Percentage of license places						

to		
Full license	%	60
Office license	%	40
Nightlicense	%	40
annual increase	%	3

Construction

Number of floors	3	
Free profile lower floor	1,9	m
Free profile other floor	2,2	m
Width automatic parking space	2,25	m
Length automatic parking space	5,375	m

		3 verd.	4 verd.	V	μ	σ	Distr.
Level top of Construction	m-NAP	3,4	3,4				
Length	m	263,2	263,2	0,01	263,2	2,63	N(μ,σ)
Width	m	13,6	13,6	0,05	13,6	0,68	N(μ,σ)
Heigth	m	9,0	11,65	0,1	9	0,90	N(μ,σ)
Number of middlefloors	stk	2	3		2	0,00	
Thickness roof	m	0,8	0,8	0,1	0,8	0,08	N(μ,σ)
Thickness outer walls	m	0,8	0,8	0,1	0,8	0,08	N(μ,σ)
Thickness floor	m	1	1	0,1	1	0,10	N(μ,σ)
Thickness middlefloors	m	0,45	0,45	0,1	0,45	0,05	N(μ,σ)
Height underwater concrete	m	1	1,5	0,25	1	0,25	N(μ,σ)
Height soil improvement	m	0,5	0,5	0,2	0,5	0,10	N(μ,σ)
Armoring	kg/m3	120	120	0,05	120	6,00	N(μ,σ)
Surface area roof and floor	m2	3.580					
Surface area parking space	m2	2.354					
m^3 Roof and parking floors	m3	2.864					
m^3 Floor	m3	3.580					
m^3 Underwater concrete	m3	3.580					
m3 outer walls	m3	3.170					
Entrances							
Number	#	7	9		7		
Additional height shank	m	6	6	0,1	5,9	0,59	N(μ,σ)
Concrete entrances	m3	617,3					
Lost parking spaces per entrance	#/verdieping/ toegang	4					
Sheet piling AZ 36-700							
Water impermeable layer	m - NAP	25					
Length	m	21,6	19,1	0,1	21,6	2,16	N(μ,σ)
Perimeter	m	554					

Profile	ton/m^2	0,169	0,169	0,05	0,169	0,01	N(μ,σ)
Tons	ton	2.021					
Strutting constant	-	115					

Piling

Foundation layer	m- NAP	18					
L	m	2	2	0	2	0,00	N(μ,σ)
B	m	2	2	0	2	0,00	N(μ,σ)
Number	stuks	895					
Length	m	5,6	3,0	0,2	5,6	1,12	N(μ,σ)

Quay wall Ruysdaelkade

Length	m	263				
Height	m	3	3	0,1	3	0,3
Thickness	m	0,6	0,6	0,1	0,6	0,1
Surface area	m^2	790				
Volume	m^3	474				

Financing

Financing reservation	k€	41000
Debt percentage	%	70
Equity	€	12300
Debt	€	28700

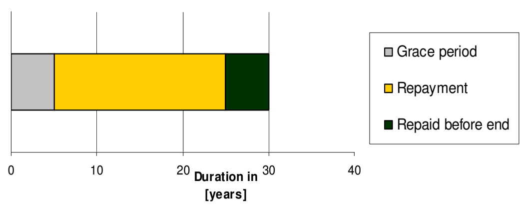
Total Funding

	2009		2010		2011		2012
	P1	P2	P1	P2	P1	P2	P1
Cash flow before debt	-11597	-9482	-1211	-4223	-7402	-2095	-1116
	31,2%	25,5%	3,3%	11,4%	19,9%	5,6%	3,0%
debt draw down schedule (perc)	30,0%	27,0%	5,0%	14,0%	24,0%	5,6%	3,0%
debt drawdown schedule (abs)	0	8779	1211	4223	7402	2095	1116
Equity	11597	703	0	0	0	0	

Tenor	yr	30	assumption: equal to project life
Repayment	yr	20	
Grace period	yr	5	
Repaid before end	yr	5	
loan life	yr	25	

Interest rate on Debt

			V	σ	Distribution
Euribor	%	4,5	0	0	N(4,5;1))
SWAP construction	%	1,5			
SWAP period 1	%	1,25			
SWAP period 2	%	1			
Financing Fee	%	1			
Commitment fee	%	0,5			
Total interest rate construction	%	7			
Total interest rate period 1	%	6,75			
Total interest rate period 2	%	6,5			



Value at end of life	x	0	EBITA multiple (last year)	0		Bookvalue	0
Working capital requirement	k€	1.000					

Other

Tax rate (avg)	%	35	90.000	35,54%	>322.000	33,99%
inflation		1,03	-322.000			
annual depreciation	%	4				

CAPEX

					V	σ		
CAPEX Parking system		€	15000		0,05	750,0	N(μ,σ)	
Depreciation	%/year	of initial CAPEX	4		0,3	1,2	N(μ,σ)	
Ongoing CAPEX construction		%	2,50					
Ongoing CAPEX installations		%	6,70					

Overhead

				V	σ	
Aannemersopslagen	%	15		0,1	1,5	N(μ,σ)
Nader te detailleren	%	10		0,1	1,0	N(μ,σ)
Object onvoorzien	%	7	8	0,1	0,7	N(μ,σ)
Voorbereiding, administratie en toezicht	%	20		0,1	2,0	N(μ,σ)
Project onvoorzien	%	7,8		0,1	0,8	N(μ,σ)
Overige kosten (leges en vergunningen)	%	7		0,1	0,7	N(μ,σ)

OPEX

				V	σ	
Maintenance system	% of capex	7		0,15	1,1	N(μ,σ)
operator	€	50.000	2009			
yearly increase in salary and maintenance	%	3				
OPEX installations	% of CAPEX installations	5				

APPENDIX VI – CALIBRATION HAND CALCULATION

In this appendix a simplified calculation is done in order to calibrate the model. The hand calculation follows the same setup as the model. Each part of the model is described in a different section in this appendix. Values used in this section are the μ-values as inputted in the model.

VI.1.1. Dimensions

The dimensions of the construction follow from the preliminary design given in appendix X. The dimensions of a parking space follow from the parking system supplier. In this calculation the construction is assumed to have 3 floors. In later stages of the research the effect of an additional floor will be discussed.

Vertical profile

$$h_{streetlevel} = 1{,}5m + NAP$$
$$h_{bottom\ Boerenwetering} = 2{,}4m - NAP$$
$$h_{topofconstruction} = 3{,}4m - NAP$$
$$h_{claylayer} = 28m - NAP$$
$$h_{sandlayer} = 18m - NAP$$

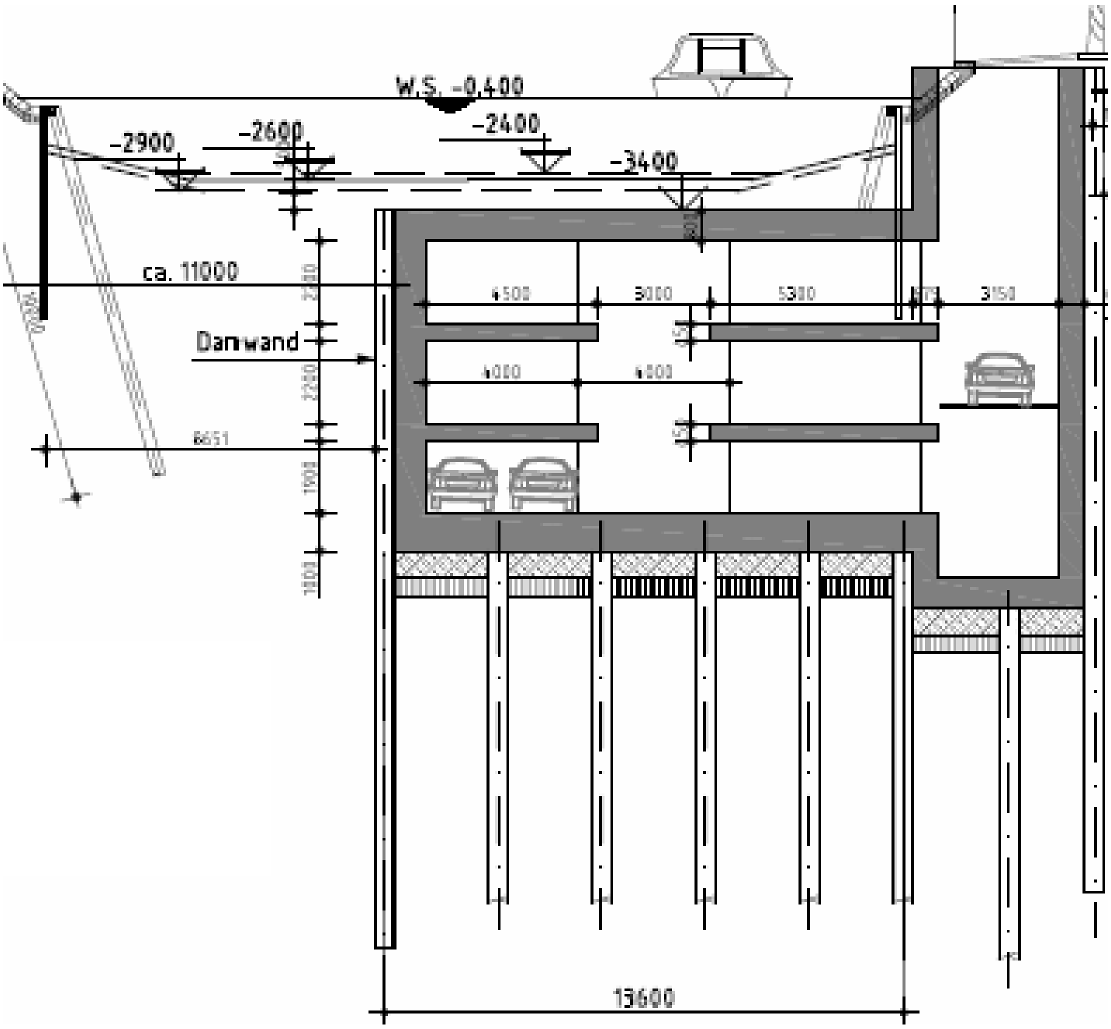


Figure 82 Drawing of the car park with an entrance

Construction dimensions

$l_{construction} = 263{,}2m$

$w_{construction} = 13{,}6m$

$h_{construction} = 1{,}9 + 2 * 2{,}2 + 0{,}8 + 1 + 2 * 0{,}45 = 9m$

$t_{roof} = 0{,}8m$

$t_{wall} = 0{,}8m$

$t_{floor} = 1m$

$t_{middle\ floors} = 0{,}45m$

Parking space characteristics

$l_{parking\ space} = 5{,}4m$

$w_{parking\ space} = 2{,}25m$

$h_{lowest\ floor} = 1{,}9m$

$h_{\ other\ floors} = 2{,}2m$

$w_{middle\ path} = 3m$

Entrances

$n_{entrances} = 7 entrances$

$n_{lost\ parking\ spaces} = 4 \quad spaces / floor / entrance$

$h_{entrance\ shank} = 1{,}5m + 3{,}4m + 1m = 5{,}9m$

From these values from the design other dimensions can be calculated

$A_{\ floor\&roof} = 263{,}2m * 13{,}6m = 3580m^2$

$A_{parking} = (263{,}2m - 2 * 0{,}8m) * (13{,}6m - 2 * 0{,}8m - 3m) = 2354{,}4m^2$

$A_{parking\ space} = 5{,}4m * 2{,}25m = 12{,}1m2$

$n_{parking\ spaces} = ((2354{,}4m^2 * 3) / 12{,}1m^2) - 7 * 4 * 3 = 500 spaces$

During construction the building pit has to be prepared. As described a construction pit is made using sheet piling. After excavation and dry pumping of the pit an underwater concrete floor is used to prevent water flowing into the pit. The top layer of soil underneath this underwater concrete As well the top layer of soil of the building pit has to be improved.

$t_{underwaterconcrete} = 1m$

$t_{soil\ \ improvement} = 0{,}5m$

$V_{excavation} = 263{,}2m * 13{,}6m * (1m + 9m + 1m + 0{,}5m + 1m) = 44.744m^3$

$m_{struts} = 230 tons$

$V_{replenishment} = 263{,}2m * 13{,}6m * 1m = 3580m^3$

The sheet piling is assumed to be a steel wall which stays in the ground. After construction the top part will be cut loose until construction height. The clay layer is expected to be located around 24m-NAP at the location of the Boerenwetering.

$l_{sheet\ piling} = 2 * (263{,}2m + 13{,}6m) = 554m$

$m_{steel} = 0{,}169 ton / m^2$

$m_{sheet\ piling} = 0{,}169 * (25m - 3{,}4m) * 554m = 2022{,}3 tons$

The construction is foundated on the sand layer 18m –NAP using piles. Assumed is that the piles are in a grid of 2 by 2 m.

$$n_{piles} = 3580m^2 / (2m * 2m) = 895 piles$$

$$l_{piles} = 18m - 3{,}4m - 9m = 5{,}6m$$

For the parking garage the quay of the Ruysdaelkade needs to be adjusted. In the first stage of construction the current quay will be replaced by a concrete one in the end of construction.

$$l_{quay} = 263{,}2m$$

$$h_{quay} = 3m$$

$$t_{concrete} = 0{,}6m$$

With the dimensions of the construction and the areas of the floors, the volumes of concrete can be calculated.

$$V_{roof} = 3580m^2 * 0{,}8m = 2864m^3$$

$$V_{floor} = 3580m^2 * 1m = 3580m^3$$

$$V_{walls\,length} = 2 * (263{,}2m - 2 * 0{,}8m) * (9{,}0m - 0{,}8m - 1{,}0m) * 0{,}8m = 3013{,}6m^3$$

$$V_{walls\,width} = 2 * 13{,}6m * (9{,}0m - 0{,}8m - 1{,}0m) * 0{,}8m = 156{,}7m^3$$

$$V_{middle\ floors} = 2 * 2354{,}4m^2 * 0{,}45m = 2119m^3$$

$$V_{inner\,walls} = 400m^3$$

$$V_{entrances} = 7 * (2 * 5{,}4m + 2 * 2{,}25m) * 0{,}8m * 5{,}90m + 7 * 2 * 2{,}25m * 0{,}8m * 0{,}5 * 9m = 617m^3$$

$$V_{quay} = 263{,}2m * 3m * 0{,}6m = 474m^3$$

For the armoring of the concrete an overall average of 120kg/m3 of armoring is assumed. This will lead to:

$$m_{armouring} = 120kg / m^3 * (2864m^3 + 3580m^3 + 3013m^3 + 156{,}7m^3 + 400m^3 + 617m^3 + 474m^3)$$
$$= 1332{,}6 tons$$

VI.1.2. Capital Expenditures (CAPEX)

The capital expenditures (CAPEX) exist of the construction costs and costs for measures in order to facilitate the construction. In the CAPEX surcharges for subcontractors and unforeseen are not included. The calculation is divided into the same cost allocation groups as the planning (see appendix III). Per group an amount and a price per amount is given. Summing al the groups will lead to the capex.

Activity	Amount	Cost/amount	Total Cost
Engineering and mobilization	-	200.000 €	€ 200.000
Destruction quay	263,2 m	1.000 €/m	€ 263.200
Insert sheet piling	2.022 tons	1.150 €/ton	€ 2.325.300
Struts	230 tons	2.000 €/ton	€ 460.000
Excavation of building pit	44.744 m3	15 €/m3	€ 671.160
Soil Improvement	1.790 m3	20 €/m3	€ 35.800
Pouring underwater concrete	3.580 m3	175 €/m3	€ 626.500
Pumping dry of building pit	-	75.000 €	€ 75.000
Placing of filter	3.580 m2	10 €/m2	€ 35.800
Fundex piling (5,9m long)	895 piles	700 €/pile	€ 626.500
Pouring concrete floor	3.580 m3	150 €/m3	€ 537.000
Pouring concrete outside walls	3.170 m3	400 €/m3	€ 1.268.000

Other concrete inner walls	400 m3	500 €/m3	€ 200.000
Placing canalplates middle floors	4.710 m2	50 €/m2	€ 235.500
Pouring concrete roof	2.864 m3	450 €/m3	€ 1.288.800
Pouring entrances	617 m3	500 €/m3	€ 308.500
Armoring	1.333 tons	1200 €/ton	€ 1.599.600
Other concrete	400 m3	500 €/m3	€ 200.000
Construction of brickworks	400 m2	75 €/m2	€ 30.000
Construction concrete quay	474 m3	400 €/m3	€ 189.600
Completion other/destruction building pit	-	€ 50.000	€ 50.000
Soil replenishment	3.580 m3	15 €/m3	€ 53.700
Installation fully automated parking places	500 spaces	11.111 €/spaces	€ 5.555.500
Installations (energy, power, light, communication, ventilation, water, fire prevention, security)	-	€ 396.800	€ 396.800
Total			**€ 17.232.260**

Table 40 Calculation of construction costs (CAPEX)

The location of the construction has large influence on the costs. Because of the lack of space and the large amount of constructions and infrastructure near the building site, surrounding costs will have a large impact on the capital expenditures.

Activity	Amount	Cost/amount	Total Cost
Trees	21 trees	2.750 €/tree	€ 57.750
Cables and pipes	-		€ 300.000
Traffic measures	-		€ 35.000
Monitoring quay	-		€ 120.000
Soil curing	-		€ 3.000.000
Other	-		€ 220.000
Total			**€ 3.732.750**

Table 41 Costs due to effects on surrounding

This will lead to a total capital expenditure of € 20.965.010,-. The result from the model calculation is € 20.963.362. The difference is due to truncation errors. In this appendix the value from the model is used in order to be able to calibrate the model easier.

For the calculation of the net present value of these cash flows, the planning should be taken into account. In order to calibrate the model, the calculation of the net present value of the CAPEX follows the same periods as the model. The costs are appointed linearly to the period they will be expected to fall. A quarter is 13 weeks. The planning is included in appendix III.

CAPEX	Cash Flow
Q1	€ 282.537
Q2	€ 401.248
Q3	€ 2.616.486
Q4	€ 2.079.674
Q5	€ 2.019.121
Q6	€ 1.028.155
Q7	€ 2.137.260

Q8	€ 3.719.922
Q9	€ 1.911.922
Q10	€ 4.767.035
Total	€20.963.362

Table 42 Quarterly timing of CAPEX

All parts of the construction have a certain lifetime. The lifetime determines the speed of deterioration of the construction. In this model the ongoing CAPEX is set as the yearly depreciation of the parts. By investing the ongoing CAPEX the construction and installations are assumed to be kept in original condition. For the determination the ongoing CAPEX different lifetimes are taken for the installations and the construction. The initial cost which is used as the base over which the percentage is taken only includes the costs of parts of the construction (excl engineering and surrounding costs). Measures taken to facilitate construction are not included. The calculation of the ongoing CAPEX is done in the table below. The ongoing CAPEX of the parking system is included in the OPEX of the parking system. For the ongoing CAPEX the start of construction is taken as index. The inflation is assumed to be 3% per year. In the model this inflation is not included.

	Design lifetime	% of initial cost	Initial cost	Ongoing CAPEX /year
Construction	40 years	2,5%	€ 11.077.843	€ 276.946
Installations	15 years	6,7 %	€ 396.800	€ 26.586
Total				**€ 303.532**

Table 43 Calculation ongoing CAPEX investments

VI.1.3.Operational expenditures

The operational expenditures consist of all the ongoing costs to run the parking garage. The OPEX of the parking system includes both OPEX and the ongoing CAPEX of the parking system. The value of 7% of the initial value is given by the supplier of the car park systems. For the OPEX the start of construction is taken as index. The inflation is assumed to be 3% per year.

	% of initial cost	Initial cost	OPEX/year
Parking system	7%	€ 5.555.969	€ 388.918
Installations	5%	€ 396.800	€ 19.840
Operator			€ 50.000
Total			**€ 458.758**

Table 44 Calculation Operational expenditures

VI.1.4. Revenues

In chapter 6 of the report the parameters for the revenue forecast of a car park are presented.

$$n_{parking\ spaces} = 500$$

$$percentage_{licensedparkingspaces} = 25\%$$

$$percentage_{shorttermparkingspaces} = 75\%$$

$$availability_{1st\ year} = 90\%$$

$$availability_{other\ years} = 98\%$$

By the phased construction parts of the car park can be used before the entire car park will be finished. By doing so revenues can be generated before the car park is entirely finished. Because the cars are placed machinally, no additional measures have to be taken. In the calculation the next numbers are used for the phasing-in of the exploitation:

50% of the total planned spaces 1 quarter before completion

75% of the total planned spaces at completion

100% of the total planned spaces 1 quarter after completion

Licensed spaces cause for a more stable and certain cash flow. Next to this it facilitates parking spaces to be removed from the streets. Additional subsidies of the city of Amsterdam are not included in the cash flow but could well be considered.

$n_{licensed\ parking\ spaces} = 125$

60% full licenses

40% office licenses

50% resident night licenses

$p_{full\ licenses} = €3000$

$p_{officelicenses} = €1800$

$p_{nightlicenses} = €1200$

$g_{annual} = 3\% / year$

The most volatile parameter in the determination of a car park is the occupation rate of the short term parking spaces. In the base case the occupation rates remain at a constant level. In practice a run-up period can be common. For the determination of the percentages and occupation rates see appendix II. For the short term parking spaces the following initial values are used.

$n_{short\ term\ parking\ spaces} = 375$

$p_{fare} = €3,80 / hour$

$Average\ weekly\ occupation\ rate = 35\%$

$g_{annual} = 3\% / year$

The calculation of the revenues in the first quarter after completion:

$Licensed\ parking\ spaces_{available} = 0,75 * 0,9 * 125 = 84 spaces$

$Revenues_{licensed\ parking\ spaces} = 84 * (1,03\char`^2) * (0,6 * 3000€ / 4 + 0,4 * 1800€ / 4 + 0,5 * €1200 / 4) = €69.820$

$Short\ term\ parking\ spaces_{available} = 0,75 * 0,9 * 375 = 253 spaces$

$Revenues_{shorttermparking} = 253 * (1,03\char`^2) * 3,80 * 0,35 * 13 * 7 * 24 = €780.034$

This calculation can be done for the entire exploitation period. For simplicity in this base case a project duration of 20 years is assumed. In the hand calculation the revenues are calculated on a yearly base. In the model this is done bi-annually. The increase in hourly fare and license costs in the start-up phase are determined each quarter. After the first three quarters these prices are determined yearly at the start of each year.

	Increase (a)	Licensed spaces (b)	Revenues per licensed spaces (c)	Short term spaces (d)	Revenues per short term parking space (e)	Total revenues (=a*b*c+ a*d*e)
Q10	1,0687	56,3	€ 750	168,8	€ 2912,7	570.567
Q11	1,0767	84,4	€ 750	253,1	€ 2912,7	861.903
Q12	1,0847	112,5	€ 750	337,5	€ 2912,7	1.157.821
Y1	1,0927	117,5	€ 3000	352,5	€ 11650,8	4.872.794
Y2	1,1255	122,5	€ 3000	367,5	€ 11682,7	5.245.834
Y3	1,1593	122,5	€ 3000	367,5	€ 11650,8	5.389.782
Y4	1,1940	122,5	€ 3000	367,5	€ 11650,8	5.551.108
Y5	1,2299	122,5	€ 3000	367,5	€ 11650,8	5.718.013
Y6	1,2668	122,5	€ 3000	367,5	€ 11682,7	5.904.418
Y7	1,3048	122,5	€ 3000	367,5	€ 11650,8	6.066.236

Y8	1,3439	122,5	€ 3000	367,5	€ 11650,8	6.248.018
Y9	1,3842	122,5	€ 3000	367,5	€ 11650,8	6.435.380
Y10	1,4258	122,5	€ 3000	367,5	€ 11682,7	6.645.500
Y11	1,4685	122,5	€ 3000	367,5	€ 11650,8	6.827.305
Y12	1,5126	122,5	€ 3000	367,5	€ 11650,8	7.032.333
Y13	1,5580	122,5	€ 3000	367,5	€ 11650,8	7.243.405
Y14	1,6047	122,5	€ 3000	367,5	€ 11682,7	7.479.334
Y15	1,6528	122,5	€ 3000	367,5	€ 11650,8	7.684.147
Y16	1,7024	122,5	€ 3000	367,5	€ 11650,8	7.914.745
Y17	1,7535	122,5	€ 3000	367,5	€ 11650,8	8.152.318
Total						**113.000.960**

Table 45 Calculation of revenues of car park

VI.1.5. Risk & Overhead

Risk includes the reserves taken into account for project unforeseen events. In appendix IV a short risk analysis is presented listing the top-10 largest risks or groups of risk. In the model the risk is allocated to a certain point in time on which the money at the earliest point in the project is should be reserved. In the analysis of flexibility of the risk, the latest point at which the cost can occur is considered. Between these points in time the unforeseen event can occur and can cause additional cost to the project.

In the cost estimation some overhead premiums are taken into account. The premiums are calculated by multiplying a percentage that follows from experience with the initial construction costs as calculated above. The sub contractor premiums are calculated as 15% over the cash flows to sub contractors in each period. Detailing and licenses are cost that will occur in the start-up phase of the project. Preparation, administration and management incur costs during the entire construction phase, however have a large share in the beginning. Therefore this cost post is assumed to fall in the first year.

	% of initial cost	Initial costs	Total	Timing
Sub contractor premium	15 %	€ 20.963.362	€ 3.144.504	Week 0 – 130
Detailing	10%	€ 20.963.362	€ 2.096.336	Week 0 -26
Preparation, administration and management	20 %	€ 20.963.362	€ 4.192.672	Week 0 – 52
Licenses and fees	7%	€ 20.963.362	€ 1.467.435	Week 0 – 26

Table 46 Overview overhead costs

For risk premiums for object unforeseen and project unforeseen respectively 10% and 14% of the initial costs are experience numbers in this phase of the project. This would result in a reserve for unforeseen events of € 4.940.426. In appendix IV a short risk analysis is given. The expected values of the risk reserves are taken into account. Since the risk analysis only covers some of the major risks, an additional amount is added as reserve for unforeseen events as “other risks”

	Risk	E[risk]	Timing
1.	Mistakes in design due to wrong assumptions	€ 506.250	Week 26-Week 130
2.	People are reluctant to use the automatic system	€ 350.000	Week 117-end

3.	Construction site can not be reached by city traffic or events	€ 215.625	Week 0 - Week 130
4.	Vibrations and other construction activities cause damage to buildings near construction site	€ 170.625	Week 26 - Week 130
5.	Affected groundwater table causes damage to building near construction site (wooden piling)	€ 170.625	Week 30- Week 117
6.	Unexpected disadvantageous soil conditions	€ 103.125	Week 26 - Week 97
7.	Other licenses are not granted (fire, groundwater, cables)	€ 83.125	Week 0 - Week 26
8.	Parking system works improperly	€ 71.250	Week 117 - end
9.	Construction license is not granted	€ 65.625	Week 0 - Week 26
10.	Archeological discovery during excavation	€ 28.125	Week 30- Week 66
11.	Other Risks	€ 3.162.015	Week 0- Week 0
Total		**€ 4.926.390**	

Table 47 Overview risk table

VI.1.6. Debt Financing

The influence of the financing structure greatly depends on the financing structure. In this study a finance structure is considered with only debt and equity. Variations with in this portions with different financing components is possible, as long as the weighted average cost of capital remains the same. The grace period is set until 1 year after exploitation since is expected that the generated cash flows will cover the interest payment. With the grace period a reserve can be made to cover the interest repayments in later stages. The debt ends two year before the end of the exploitation period. This way in the last two years the return on equity can be made. This period is required to be long enough to make sure by the banks that the interest is paid back in time.

$$t_{debt} = 18 years$$
$$t_{grace} = 4 years$$
$$t_{repayment} = 14 years$$

Figure 83 Relationship between phases of debt financing

The interest rate depends on the risk of the project in that phase. This risk will be high in the construction phase due to the high uncertainty. After a year of exploitation this rate will drop due to expected lower uncertainty. The rates greatly depend on the market situation, negotiations and the tendency towards risk. In this study the interest rates are assumed at:

$r_{Euribor10yr} = 3,5\%$

$r_{SWAP;construction} = 1,5\%$

$r_{SWAP;1styear\,exploitation} = 1,25\%$

$r_{SWAP;exploitation} = 1\%$

$r_{financingfee} = 1\%$

$r_{commitment\ fee} = 0,5\%$

This results for the interest rates

$r_{construction} = 6\%$

$r_{1styear\,exploitation} = 5,75\%$

$r_{exploitation} = 5.5\%$

The financing need is determined by all the cash flows until the exploitation phase including the financing costs. The financing structure is estimated based on experience numbers. The drawdown schedule is taken similar as the financing need per period.

$Financing\ need = €40.000.000$

$Debt\ percentage = 70\%$

$Debt = €28.000.000$

$Working\ capital = €0$

$Drawdownschedule$

$Debt_{Q1Q2} = 30\%$

$Debt_{Q3Q4} = 22\%$

$Debt_{Q5Q6} = 10\%$

$Debt_{Q7Q8} = 18\%$

$Debt_{Q9Q10} = 20\%$

	Q1&Q2	Q3&Q4	Q5&Q6	Q7&Q8	Q9&Q10
Debt committed	28.000.000	19.600.000	13.440.000	10.640.000	5.600.000
Total Debt	0	8.400.000	14.560.000	17.360.000	22.400.000
Debt drawn	8.400.000	6.160.000	2.800.000	5.040.000	5.600.000

Table 48 Debt schedule

In project finance by a bank three major fees are determining the finance costs. Financing costs are the costs that the bank requires during the construction. The commitment fees are fees for the money reserved by the bank for the project. The Interest During Construction (IDC) is the interest rate on the debt that is drawn during construction already. The financing fee is a one-time fee for administrational and banking expenses. These fees are calculated as below. The fees over the entire construction time determine the financing costs.

$$IDC_{Q1Q2} = (1,05^{\frac{1}{2}} - 1) * (8.400.000/2 + 0) = 103.719$$

$$CommitmentFee = (1,005^{\frac{1}{2}} - 1) * (28.000.000 - 8.400.000/2) = 59.426$$

$$FinancingFee = 28.000.000 * 0,01 = 280.000$$

	Q1&Q2	Q3&Q4	Q5&Q6	Q7&Q8	Q9&Q10

IDC	103.719	283.499	394.133	490.938	622.316
Commitment Fee	59.426	41.249	30.062	20.275	6.991
Financing Fee	280.000				
Total	**443.145**	**324.748**	**424.196**	**511.213**	**629.307**

Table 49 Calculation of financing costs

After the construction is finished interest should be paid and the total debt repaid. The debt is repaid linearly over the repayment period. In the model the interest is paid biannually. By making biannual repayments less interest on interest has to be paid. Although the percentage is very small, due to the large debt size the amount can be considerable. With the short calculation below, the difference between biannual and annual interest payments is shown in this case.

$$interest_{difference} = 1{,}0575 - 2*(1{,}0575^{\frac{1}{2}} - 1) = 0{,}08\%$$

$$Debt_{average} = 14.000.000$$

$$interest_{difference} = €11.200/year$$

$$Interest_{difference} = €196.000$$

$$(NPV_{interestdifference}\ (7{,}5\%) = €93.000)$$

In the hand calculation this difference is taken into account by averaging the interest payments over a year. The interest is paid over the debt at the beginning of each period. In order to reduce the costs by interest over interest, the interest payments are calculated by:

$$Interest_{Y5} = 2*(1{,}0575^{\frac{1}{2}} - 1)*(28.000.000 - (\frac{1}{4}*2.000.000))$$

	Debt at begin of period (a)	Debt repayment (b)	Interest rate	Interest payment (c)	Debt at end of the period (=a-b)	Total Debt Service (=b+c)
Q11&12	28.000.000	0	5,75%	793.749	28.000.000	793.749
Y4	28.000.000	0	5,75%	1.587.499	28.000.000	1.587.499
Y5	28.000.000	2.000.000	5,75%	1.559.150	26.000.000	3.559.150
Y6	26.000.000	2.000.000	5,63%	1.415.993	24.000.000	3.415.993
Y7	24.000.000	2.000.000	5,50%	1.275.201	22.000.000	3.275.201
Y8	22.000.000	2.000.000	5,50%	1.166.673	20.000.000	3.166.673
Y9	20.000.000	2.000.000	5,50%	1.058.145	18.000.000	3.058.145
Y10	18.000.000	2.000.000	5,50%	949.618	16.000.000	2.949.618
Y11	16.000.000	2.000.000	5,50%	841.090	14.000.000	2.841.090
Y12	14.000.000	2.000.000	5,50%	732.562	12.000.000	2.732.562
Y13	12.000.000	2.000.000	5,50%	624.034	10.000.000	2.624.034
Y14	10.000.000	2.000.000	5,50%	515.507	8.000.000	2.515.507
Y15	8.000.000	2.000.000	5,50%	406.979	6.000.000	2.406.979
Y16	6.000.000	2.000.000	5,50%	298.451	4.000.000	2.298.451
Y17	4.000.000	2.000.000	5,50%	189.924	2.000.000	2.189.924
Y18	2.000.000	2.000.000	5,50%	81.396	0	2.081.396
Y19	0	0	0%	0	0	0
Y20	0	0	0%	0	0	0

Total							

Table 50 Calculation of debt service

VI.1.7. Depreciation of the construction

Depreciation of the construction reduces the book value of the construction. The depreciation in a year can be taken as a loss and therefore reduces the taxes. The depreciation sets in when the construction stops In order to determine the depreciation the cumulative value of capital should be determined as follows.

$$Cum.Capital = CAPEX + Risk\,\&\,Overhead + CapitalizedExpenses + OngoingCAPEX$$
$$TotalCAPEX = €20.963.362$$
$$Risk\,\&\,Overhead = 4.926.390 + 3.144.504 + 2.096.336 + 4.192.672 + 1.467.435 = €15.827.334$$
$$CapitalizedExpenses = 443.145 + 324.748 + 424.196 + 511.213 + 629.307 = €2.332.609$$
$$OngoingCAPEX = €303.532$$

At the start of the exploitation phase the cumulative Capital is € 39.123.305,-. When the exploitation commences the book value of the construction is determined by two factors. The value increases by the ongoing CAPEX and decreases by the yearly depreciation. The depreciation is taken as 4% (overall lifetime 25 years).

In the model the depreciation is determined biannually at the end of the half year period. Therefore the depreciation in each period is calculated as:

$$D_{Y4} = 2 * (1{,}04^{\frac{1}{2}} - 1) * (39.286.711 + \frac{3}{4} * 336.616) = €1.566.060$$

	Bookvalue begin	Ongoing CAPEX	Depreciation
Q11&12	39.123.305	163.406	€ 773.411
Y4	39.286.711	336.616	€ 1.566.060
Y5	39.623.327	346.714	€ 1.579.692
Y6	39.970.041	357.116	€ 1.593.734
Y7	40.327.157	367.829	€ 1.608.197
Y8	40.694.986	378.864	€ 1.623.094
Y9	41.073.850	390.230	€ 1.638.437
Y10	41.464.080	401.937	€ 1.654.241
Y11	41.866.017	413.995	€ 1.670.519
Y12	42.280.012	426.415	€ 1.687.286
Y13	42.706.427	439.208	€ 1.704.555
Y14	43.145.635	452.384	€ 1.722.342
Y15	43.598.019	465.955	€ 1.740.663
Y16	44.063.974	479.934	€ 1.759.534
Y17	44.543.908	494.332	€ 1.778.971
Y18	45.038.240	509.162	€ 1.798.991
Y19	45.547.402	524.437	€ 1.819.611
Y20	46.071.839	540.170	€ 1.840.851
Total			**€29.560.189**

Table 51 Calculation of depreciation

VI.1.8. Taxes

Taxes are paid over the net operating income – depreciation – interest payments. The tax rate in the Netherlands is 35,5 % if the taxable profit is between 94.000 and 322.000. Above this amount the tax rate is 34%. In this case a average tax rate of 35% is assumed. The calculation is done in the table of the cash flow overview below.

In the leveraged case the interest payments are tax deductible. Therefore paying interest reduces the amount tax paid. In the not leveraged case this increases the tax payments significantly. This effect is related to in literature as Interest Tax Shield (ITS). This tax advantage makes debt financing attractive.

VI.1.9. Working Capital and Value at the end of lifetime

In the hand calculation the effect of the working capital reservations and the value at the end of the life time are not included. In the model these parameters can be taken into account.

The working capital leads to an extra withdrawal of money at the start of the project which is returned to the equity holders when it is not needed anymore. Because this money is needed during the project no return is made on this money. This will lead to opportunity costs discounted at the required return on equity, For example with a discount rate of 7,5% and a working capital requirement of € 1.000.000 this leads after 3 years to a foregone costs of:

$$1.000.000-\frac{1.000.000}{1{,}075^{3}}=€195.000$$

The construction still has a value at the end of the project lifetime. If the construction including exploitation is sold at the end of the project life time, an additional profit/loss can be made. The price of an asset is generally a multiple of the last made year profit (depending on type of industry 4 – 12 times EBITA). Considering the high demand for parking spaces in Amsterdam, high investments costs of a car park and difficulties of replacing parking spaces, a EBITA multiple of 4 could be realistic. Next to this the construction has a bookvalue of all CAPEX minus all depreciation. The difference between the price for which the car park could be sold and the bookvalue of the construction is an extraordinary profit/loss for the car park owner. In relative short project durations this can lead to a considerable increase in net present value. With longer project durations, the effect of the profit at the end of the lifetime reduces significantly.

$$\text{Expected Bookvalue} = €46.071.839 - €29.560.189 = €16.511.650$$

$$\text{Market value} = 4 * 4.954.000 = €19.816.000$$

$$\text{Etraordinary profit} = €3.304.350$$

$$NPV(7{,}5\%) = €740.000$$

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Revenues										570.567	861.903	1.157.821
- CAPEX	282.537	401.248	2.616.486	2.079.674	2.019.121	1.028.155	2.137.260	3.719.922	1.911.922	4.767.035	81.703	81.703
- OPEX										63.448	92.614	123.486
- Subcontr. premium	42.381	60.187	392.473	311.951	302.868	154.223	320.589	557.988	286.788	715.055		
- Overhead	2.830.054	2.830.054	1.048.168	1.048.168								
- Risk	3.526.390		978.750							421.250		
- Financing costs	221.573	221.573	162.374	162.374	212.098	212.098	255.606	255.606	314.654	314.654		
Net Operating Income	-6.902.934	-3.513.062	-5.198.251	-3.602.167	-2.534.087	-1.394.476	-2.713.455	-4.533.517	-2.513.364	-5.710.876	687.586	952.632
Depreciation											386.705	386.705
- Taxes											-33.598	59.168
+ Profit on sales												
Operating Cash Flow	-6.902.934	-3.513.062	-5.198.251	-3.602.167	-2.534.087	-1.394.476	-2.713.455	-4.533.517	-2.513.364	-5.710.876	721.184	893.464
- Interest payment											396.875	396.875
- Debt repayment											0	0
Equity funding	902.934	1.113.062	1.298.251	1.342.167	534.087	594.476	1.113.455	1.093.517	1.513.364	1.110.876		
Debt funding	6.000.000	2.400.000	3.900.000	2.260.000	2.000.000	800.000	1.600.000	3.440.000	1.000.000	4.600.000		
Change in Cash	0	0	0	0	0	0	0	0	0	0	324.309	496.589
Cash Flow to Equity	-902.934	-1.113.062	-1.298.251	-1.342.167	-534.087	-594.476	-1.113.455	-1.093.517	-1.513.364	-1.110.876	324.309	496.589

	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Revenues	4.872.794	5.245.834	5.389.782	5.551.108	5.718.013	5.904.418	6.066.236	6.248.018	6.435.380	6.645.500	6.827.305	7.032.333	7.243.405	7.479.334	7.684.147	7.914.745	8.152.318
- CAPEX	336.616	346.714	357.116	367.829	378.864	390.230	401.937	413.995	426.415	439.208	452.384	465.955	479.934	494.332	509.162	524.437	540.170
- OPEX	508.761	524.024	539.745	555.937	572.615	589.794	607.487	625.712	644.483	663.818	683.732	704.244	725.372	747.133	769.547	792.633	816.412
- Subcont. premium																	
- Overhead																	
- Risk																	
- Financing costs																	
Net Operating Income	4.027.417	4.375.096	4.492.921	4.627.341	4.766.534	4.924.394	5.056.811	5.208.311	5.364.481	5.542.475	5.691.188	5.862.133	6.038.100	6.237.869	6.405.438	6.597.675	6.795.736
Depreciation	1.566.060	1.579.692	1.593.734	1.608.197	1.623.094	1.638.437	1.654.241	1.670.519	1.687.286	1.704.555	1.722.342	1.740.663	1.759.534	1.778.971	1.798.991	1.819.611	1.840.851
- Taxes	305.850	432.688	519.118	610.380	691.868	779.734	858.533	943.846	1.030.622	1.124.860	1.208.669	1.300.072	1.393.040	1.494.141	1.583.768	1.672.322	1.734.210
+ Profit on sales																	
Operating Cash Flow	3.721.566	3.942.407	3.973.803	4.016.961	4.074.665	4.144.660	4.198.278	4.264.465	4.333.859	4.417.615	4.482.520	4.562.062	4.645.060	4.743.728	4.821.670	4.925.353	5.061.526
- Interest payment	1.587.499	1.559.150	1.415.993	1.275.201	1.166.673	1.058.145	949.618	841.090	732.562	624.034	515.507	406.979	298.451	189.924	81.396	0	0
- Debt repayment	0	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000		
Equity funding																	
Debt funding																	
Change in Cash	2.134.068	383.257	557.810	741.760	907.992	1.086.515	1.248.660	1.423.375	1.601.297	1.793.580	1.967.013	2.155.083	2.346.608	2.553.804	2.740.274	4.925.353	5.061.526
Cash Flow to Equity	2.134.068	383.257	557.810	741.760	907.992	1.086.515	1.248.660	1.423.375	1.601.297	1.793.580	1.967.013	2.155.083	2.346.608	2.553.804	2.740.274	4.925.353	5.061.526

VI.1.10. Calculation of Net Present Value

If the overview of the cash flows is calculated, now the net present value of the project without strategic value can be determined. In this calculation a return on equity of 7,5% is assumed.

The Net Present Value of the not leveraged cash the operating cash flow is discounted to the present. Attention has to be paid on the paid taxes in the non-leveraged case. Paid interest can be deducted from the net cash flow, which results in a lower taxable profit. Therefore the non-leveraged scenario pays more taxes than the leveraged scenario. This effect is described in literature as the interest tax shield (ITS). To calculate the net present value of the leveraged case the cash flows to equity have to be discounted.

7,5%	Net cash flow	Cash Flow to equity	Discount factor	Discounted - no leveraging	Discounted leveraged
Q1	-6.902.934	-902.934	0,991	-6.840.813	-894.809
Q2	-3.513.062	-1.113.062	0,973	-3.419.067	-1.083.281
Q3	-5.198.251	-1.298.251	0,956	-4.968.519	-1.240.876
Q4	-3.602.167	-1.342.167	0,939	-3.381.282	-1.259.865
Q5	-2.534.087	-534.087	0,922	-2.336.076	-492.354
Q6	-1.394.476	-594.476	0,905	-1.262.480	-538.205
Q7	-2.713.455	-1.113.455	0,889	-2.412.592	-989.997
Q8	-4.533.517	-1.093.517	0,873	-3.958.625	-954.849
Q9	-2.513.364	-1.513.364	0,858	-2.155.323	-1.297.778
Q10	-5.710.876	-1.110.876	0,842	-4.809.585	-935.558
Q11	582.278	324.309	0,827	481.596	268.233
Q12	754.558	496.589	0,812	612.905	403.365
Y4	3.165.942	2.134.068	0,776	2.457.952	1.656.832
Y5	3.396.705	383.257	0,722	2.453.125	276.791
Y6	3.478.206	557.810	0,672	2.336.731	374.749
Y7	3.570.641	741.760	0,625	2.231.470	463.563
Y8	3.666.330	907.992	0,581	2.131.415	527.860
Y9	3.774.309	1.086.515	0,541	2.041.106	587.576
Y10	3.865.912	1.248.660	0,503	1.944.785	628.151
Y11	3.970.084	1.423.375	0,468	1.857.851	666.086
Y12	4.077.463	1.601.297	0,435	1.774.977	697.067
Y13	4.199.203	1.793.580	0,405	1.700.439	726.298
Y14	4.302.092	1.967.013	0,377	1.620.561	740.957
Y15	4.419.619	2.155.083	0,350	1.548.681	755.164
Y16	4.540.602	2.346.608	0,326	1.480.070	764.908
Y17	4.677.255	2.553.804	0,303	1.418.245	774.369
Y18	4.793.181	2.740.274	0,282	1.351.997	772.940
Y19	4.925.353	4.925.353	0,262	1.292.352	1.292.352
Y20	5.061.526	5.061.526	0,244	1.235.425	1.235.425
NPV				**-3.572.681**	**3.925.113**

The Net Present Value of the not-leveraged case is - € 3.573.000 (model: -€3.431.000) In the leveraged scenario the Net Present Value is + € 3.925.000 (model: + €3.954.000). The differences between the hand calculation and the model can be explained by the relative big spread of the cash flows in the first year. In the model the cash flows are assumed to be distributed linearly over the year. In the hand calculation the cash flows are discounted per quarter. If the values in the above table would be aggregated per year, the exact same values would be found as the model gives.

The difference between the leveraged case and the not leveraged case shows the influence on feasibility of debt financing. Due to the lower interest rate on debt than on equity and the effect of the interest tax shield (ITS) the debt financed case shows a higher NPV.

VI.2. Variations of number of floors

The model calculations can be repeated for any variation of the input parameters. The model is set up such that all the underlying base assumptions are in the assumptions sheet. In this section the assumptions and dependencies of varying the number of floors in the model are described. The calculations follow the same structure as described in the hand calculation above. The calculation with 4 parking desk is not repeated here.

VI.2.1. Dimensions

The 4th floor in the car park will be 2,2 m high with an extra floor of 0,45m thick. The other construction dimensions stay the same. This results in:

$$h_{construction} = 1{,}9m + 3 * 2{,}2m + 0{,}8m + 1m + 3 * 0{,}45m = 11{,}65m$$

The outer dimensions of the car park remain the same. If the number of entrance houses are kept the same this will result in:

$$n_{parking\ spaces} = ((2354{,}4m^2 * 4)/12{,}1m^2) - 7 * 4 * 4 = 666 spaces$$

A critical point in an automatic car park can is the throughput time. To keep this the same as the car park with 3 floors and 7 entrances, additional entrances are needed. From appendix I it follows that 60% of the resident need a parking space at home during the day. This means that the parking system needs to handle about 40% of the parking spaces in about 1 hour. So for the three storey car park this means:

$$n_{exchanges} = 0{,}4 * 500\ spaces = 200 cars/hour$$

$$n_{exchanges} = 200\ cars/7\ entrances = 28{,}5\ cars/hour/entrance$$

$$t_{average\ exchange} = \frac{60\ min}{28{,}5} = 2min\ 6sec$$

This is above the system feature of 2 minutes of handling time per car. This time could be lowered by programming of the system and optimization by analyzing arrival patterns. For now we assume an average exchange time of 2 minutes. For the 4 storey car park then holds:

$$n_{exchanges} = 0{,}4 * 666\ spaces = 266\ cars/hour$$

$$t_{average\ exchange} = 2\ min$$

$$n_{entrances} = 266/30 = 8{,}8\ entrances$$

So rounded this means at least 9 entrances are needed in order to be able to handle enough cars at the peak of car exchanges. For the number of parking spaces is then:

$$n_{parking\ spaces} = ((2354{,}4m^2 * 4)/12{,}1m^2) - 9 * 4 * 4 = 634\ spaces$$

$$t_{averageexchange} = \frac{60}{0{,}4 * \frac{634}{9}} = 2\ min\ 8\ sec$$

For the construction phase the next assumptions are made. The sheet piling remains unchanged. However to secure the water tightness of the building pit, the underwater concrete floor is assumed to be thicker.

$$t_{underwaterconcrete} = 1{,}5m$$

$$V_{excavation} = 263{,}2m * 13{,}6m * (1m + 11{,}65m + 1{,}5m + 0{,}5m + 1m) = 56.019m^3$$

$$m_{struts} = 1{,}5 * 230tons = 345tons$$

$$l_{piles} = 18m - 3{,}4m - 11{,}65m = 3m$$

For the amount of concrete and armoring follows:

$$V_{walls\ length} = 2*(263,2m - 2*0,8m)*(11,65m - 0,8m - 1,0m)*0,8m = 4123m^3$$

$$V_{walls\ width} = 2*13,6m*(11,65m - 0,8m - 1,0m)*0,8m = 214,3m^3$$

$$V_{middle\ floors} = 3*2354,4m^2*0,45m = 3178m^3$$

$$V_{inner\ walls} = 533m^3$$

$$V_{entrances} = 9*(2*5,4m + 2*2,25m)*0,8m*5,90m + 9*2*2,25m*0,8m*0,5*11,65m = 839m^3$$

$$m_{armouring} = 120kg/m^3*(2864m^3 + 3580m^3 + 4123m^3 + 214,3m^3 + 533m^3 + 839m^3 + 474m^3)$$

$$= 1515,3tons$$

VI.2.2. CAPEX and planning

With the increase of the size of the construction pit relative to the three storey car park, the total capital expenditures and the planning face increases as well. In the model price increases due to extra amounts of material are included in the calculation with unit prices. Next to this, an increase can be expected in the planning. If the activity is done for the same unit price it will take longer. Another option would be to complete the larger activity in the same time but with increasing unit prices. So for each construction activity that is affected by the additional floor a decision has to be made between:

- Increasing costs in the same construction time as the base case
- Increasing the construction time for the same price per unit as the base case

In this section the changes in unit price or planning are listed:

	T-value	5%	95%
Struts (50% increase in amount)	8 weeks	6 weeks	10 weeks
Excavation of building pit (25,2% increase in amount)	27 weeks	22 weeks	42 weeks
Pouring underwater concrete (50% increase in amount)	5 weeks	4 weeks	7 weeks
Installation fully automated parking system (26,8% increase in number)	20 weeks	15 weeks	32 weeks
Installations (33 % increase in amount)	20 weeks	15 weeks	32 weeks

Table 52 Activities with longer construction time relative to base case

In some cases the construction method or possibilities to increase the construction speed will require an increase in price. The pouring of a 20m long element in one week is still useful with reuse of equipment and phasing of construction. Therefore in these cases the construction time is kept constant and the price is increased.

	T-value	5%	95%
Pumping dry of building pit (25,2% increase in amount)	€ 93.900	-	-
Fundex Piling (95% decrease in length)	€ 350 (=€120/m*2,95m)	€ 300	€ 400
Pouring concrete outside walls (37% increase in concrete)	€ 425	€ 325	€ 525

Other concrete inner walls (33% increase in concrete)	€ 525	€ 425	€ 625
Placing canal plates middle floors (50% increase in amount)	€ 55	€ 45	€ 65
Pouring entrances (28,5% increase in amount)	€ 525	€ 425	€ 625
Armoring	€ 1300	€ 1100	€ 1500

Table 53 Activities with increased unit prices relative to base case

For the planning this results in an average construction time of 11,85 quarters, which is around 2,5 months longer than the 3 storey car park. The total initial CAPEX will increase to around € 24.100.000. The percentages for ongoing CAPEX and OPEX do not vary. These amounts will increase linearly with the increased initial costs on which they are calculated in the model.

VI.2.3. Revenues

If additional parking spaces in the area would be created the demand would drop which could affect the occupation rates. However, in the policy of the city of Amsterdam, the additional created parking spaces are removed on ground level. This way the extra parking capacity will not affect the occupation rates. As well the distribution over the different licenses is kept constant.

$$n_{licensed\ parking\ spaces} = 159\ spaces$$

$$n_{short\ term\ parking\ spaces} = 475\ spaces$$

VI.2.4. Risk & Overhead

In the model the premiums for subcontractors, detailing, overall preparation and licenses, are calculated as surcharges on the initial CAPEX. The percentages are kept constant in comparison to the base case. However the initial CAPEX increased as described above.

With increasing depth the risks of the project will increase significantly. This increase in riskiness of the project has two causes

- A sand layer is a located at around 12m – NAP. In the base case with three layers this layer acts advantageous. Both because of possible head differences that may exist underneath the layer. Secondly the weight of the layer is beneficial to prevent the construction pit from failure and the construction from drifting. Therefore an extra thick layer under water concrete is necessary for prevention of these mechanisms.
- A deeper building pit will cause a higher groundwater head difference. Risks related to leakage of the building pit, unwanted groundwater flows and damage to surrounding constructions due to the affected ground water table will increase.

For this reason the object unforeseen is raised to 11%. This results in an additional risk premium for these two risks of about € 2,4 Mio.

VI.2.5. Debt Financing

With increased construction costs, the financing need is also raised. For a first estimation for the financing reservations the total expenses can be calculated:

$$Expenses = CAPEX + Risk\,\&\,Overhead + CapitalizedExpenses$$
$$TotalCAPEX = €24.048.000$$
$$Risk\,\&\,Overhead = €18.396.700$$
$$Financing\ costs = €2.799.000$$

$$Total\ Expenses = €45.243.700$$
$$Financing\ need = €48.000.000$$

To cover for the risk of project insolvency, a financing reservation a debt of €48.000.000 is used as input for the 4 storey car park. In a Monte-Carlo simulation the risk of insolvency can be researched further in detail. Depreciation and interest rates are kept constant in comparison to the base case.

VI.2.7. Results base calculation 4 storey car park

Is these assumptions and dependencies are calculated through, the next results are obtained:

	3 storey car park	4 storey car park
Total construction costs	€ 39.123.305	€ 45.243.700
Duration of construction	143 weeks	154 weeks
NPV leveraged case	+ € 3.925.000	€ 7.640.000
NPV unleveraged case	- € 3.573.000	- € 1.221.000

VI.3. Rough sensitivity analysis of parameter on NPV

With a quick scan by a hand calculation insight can be obtained of the robustness of the results. In this section a rough sensitivity check is done by hand calculation to get an overview of the influence of certain parameters of the model.

VI.3.1. Construction costs

The case of a 3 storey car park the NPV results in a value + € 3.925.000. Since the majority of the costs fall in the first two years, budget overruns can have a large impact on the project its feasibility. In the base case the total construction costs run up to € 39.123.305. This means that a budget overrun of about 10% is possible before the WACC of 7,5% is not reached.

VI.3.2. Ongoing CAPEX

The effect of a variation of the ongoing CAPEX can be investigated by discounting the cash flows spend on the ongoing CAPEX. With a discount rate of 7,5 % this calculation is presented in the table below. In the table below that the effects of a -10% and a +10% variation of the total size of the ongoing CAPEX is given.

Q11	-81.703	0,827	-67.576
Q12	-81.703	0,812	-66.365
Y4	-336.616	0,776	-261.340
Y5	-346.714	0,722	-250.400
Y6	-357.116	0,672	-239.918
Y7	-367.829	0,625	-229.875
Y8	-378.864	0,581	-220.252
Y9	-390.230	0,541	-211.032
Y10	-401.937	0,503	-202.198
Y11	-413.995	0,468	-193.734

Y12	-426.415	0,435	-185.624
Y13	-439.208	0,405	-177.854
Y14	-452.384	0,377	-170.409
Y15	-465.955	0,350	-163.276
Y16	-479.934	0,326	-156.441
Y17	-494.332	0,303	-149.892
Y18	-509.162	0,282	-143.618
Y19	-524.437	0,262	-137.606
Y20	-540.170	0,244	-131.846
NPV			**-3.359.255**

Table 54 Discounted cash flows from ongoing CAPEX

Scenarios of ongoing CAPEX costs	NPV of cash flows of ongoing CAPEX
-10 %	-€ 3.023.300
Base case	-€ 3.359.300
+ 10 %	-€ 3.695.200

VI.3.3. OPEX

Scenarios of OPEX	NPV of cash flows of OPEX
-10 %	- € 4.665.600
Base case	- € 5.184.000
+ 10 %	- € 5.702.500

VI.3.4. Volatility of the parking fare

Scenarios of parking fares	NPV of project
€ 3,40/hour (-10 %)	+ € 715.200
€ 3,80/hour	+ € 3.925.000
€ 4,20/hour (+10 %)	+ € 7.135.100

VI.3.5. Volatility in average weekly occupation rate

Scenarios of occupation rates	NPV of project
30 %	-€ 431.200
35 %	+ € 3.925.000
40 %	+ € 8.281.500

VI.3.6. Variations in discount rate

The cash flows are discounted using the WACC. The WACC can be seen as the return that is required for taking on the risk that is associated with investing in this car park. From experience numbers follows that around 7% is common for car parks. However, since there is not much experience with fully automated car parks in the Netherlands, the riskiness of exploitation is estimated to be higher. In the base case therefore a value of 7,5 % is taken.

The effect of the WACC can be shown discounting the cash flows with a different WACC. In the table below this is done for a discount rate of 5%. From this calculation follows that the NPV in the not leveraged case will be + € 4.397.000 and in the leveraged case + € 8.129.432.

	Net cash flow (not leveraged)	Cash Flow (leveraged case)	Discount factor	Discounted - no leveraging	Discounted leveraged
Q1	-6.902.934	-902.934	0,994	-6.860.963	-897.444
Q2	-3.513.062	-1.113.062	0,982	-3.449.370	-1.092.882
Q3	-5.198.251	-1.298.251	0,970	-5.042.129	-1.259.260
Q4	-3.602.167	-1.342.167	0,958	-3.451.622	-1.286.074
Q5	-2.534.087	-534.087	0,947	-2.398.742	-505.562
Q6	-1.394.476	-594.476	0,935	-1.303.994	-555.903
Q7	-2.713.455	-1.113.455	0,924	-2.506.629	-1.028.585
Q8	-4.533.517	-1.093.517	0,913	-4.137.188	-997.920
Q9	-2.513.364	-1.513.364	0,902	-2.265.834	-1.364.320
Q10	-5.710.876	-1.110.876	0,891	-5.086.021	-989.330
Q11	582.278	324.309	0,880	512.281	285.323
Q12	754.558	496.589	0,869	655.803	431.597
Y4	3.165.942	2.134.068	0,843	2.668.950	1.799.060
Y5	3.396.705	383.257	0,803	2.727.131	307.707
Y6	3.478.206	557.810	0,765	2.659.586	426.526
Y7	3.570.641	741.760	0,728	2.600.254	540.173
Y8	3.666.330	907.992	0,694	2.542.797	629.742
Y9	3.774.309	1.086.515	0,661	2.493.035	717.673
Y10	3.865.912	1.248.660	0,629	2.431.944	785.500
Y11	3.970.084	1.423.375	0,599	2.378.549	852.770
Y12	4.077.463	1.601.297	0,571	2.326.554	913.682
Y13	4.199.203	1.793.580	0,543	2.281.921	974.663
Y14	4.302.092	1.967.013	0,518	2.226.508	1.018.009
Y15	4.419.619	2.155.083	0,493	2.178.412	1.062.231
Y16	4.540.602	2.346.608	0,469	2.131.470	1.101.556
Y17	4.677.255	2.553.804	0,447	2.091.065	1.141.732
Y18	4.793.181	2.740.274	0,426	2.040.850	1.166.759
Y19	4.925.353	4.925.353	0,406	1.997.263	1.997.263
Y20	5.061.526	5.061.526	0,386	1.954.745	1.954.745
NPV				**4.396.624**	**8.129.432**

Table 55 Discounted cash flows with a discount factor of 5%

If this is done for more discount rates as well the internal rate of return (IRR) can be calculated. In the table below the effects of this variation is shown.

	Not leveraged case	Leveraged case
5 %	+ € 4.396.624	+ € 8.129.432
7,5 %	- € 3.572.681	+ € 3.925.000
10 %	- € 9.180.162	+€ 1.058.686
IRR	**6,27 %**	**11,22 %**

Table 56 Effect of varying the discount rate (WACC) on the NPV

APPENDIX VII – SENSITIVITY ANALYSIS

A sensitivity analysis is done in order to get insight into the influence of the uncertainty of each parameter on the result. This analysis is done by determining the regression coefficient of each parameter on the NPV. This coefficient shows how much the NPV will change if only the input parameter is changed with one standard deviation keeping every other parameter fixed. With this approach it is assumed that all parameters are independent and can be linearized.

The sensitivity analysis is done by running a Monte Carlo simulation for each parameter. The spread in the answers is plotted versus the spread of the input parameter. A linear regression line is drawn through the (cloud of) points. The linear coefficient in this linear regression function is the regression coefficient, showing how much the NPV changes when the input parameter varies with 1 standard deviation. The standard deviation for the binomial distribution is determined by

$$\sigma = \sqrt{np(1-p)}$$

In chapter 11 the top-10 list of regression coefficients for the entire project is shown. In this appendix the extensive results from the sensitivity analysis are shown. In Figure 84 the regression coefficients for the amount parameters are shown, in Figure 85 the coefficients for the price parameters and in Figure 86 those for the parameters from the risk analysis. For the assumed distribution per parameter, see appendix III and V.

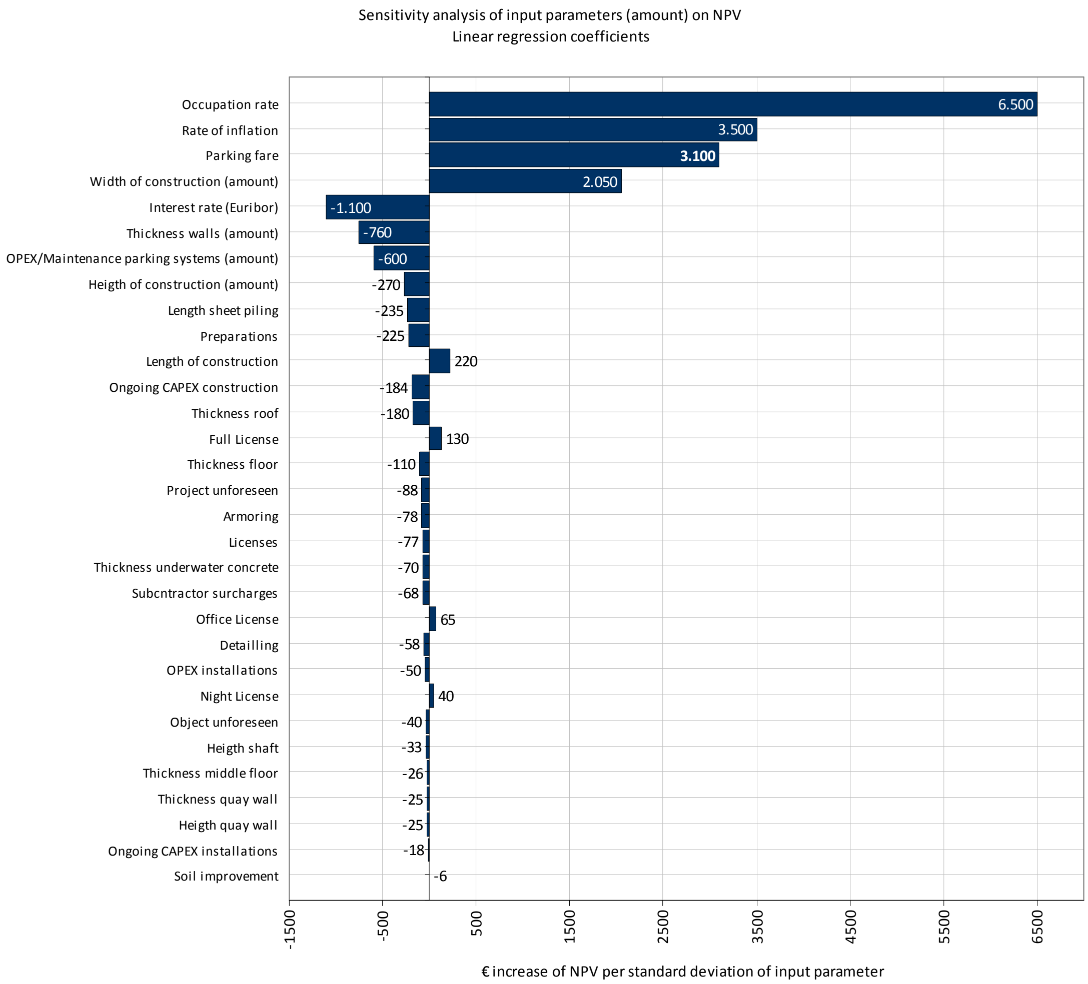


Figure 84List of regression coefficients for amount input parameters

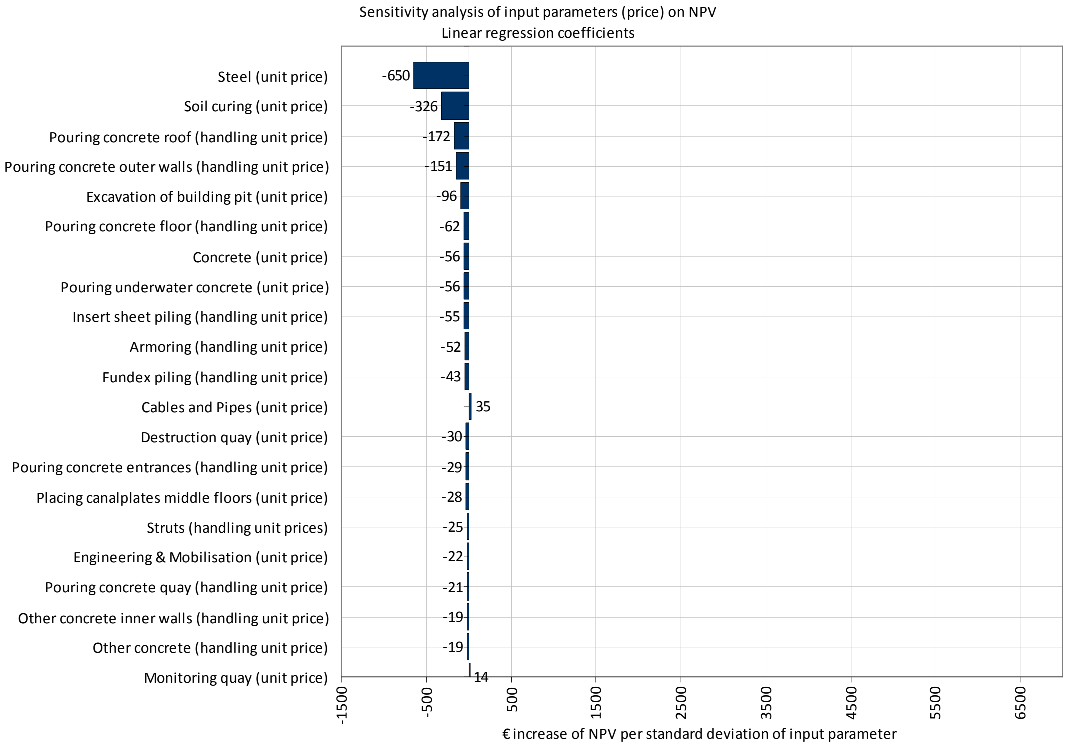


Figure 85 List of regression coefficients for price input parameters

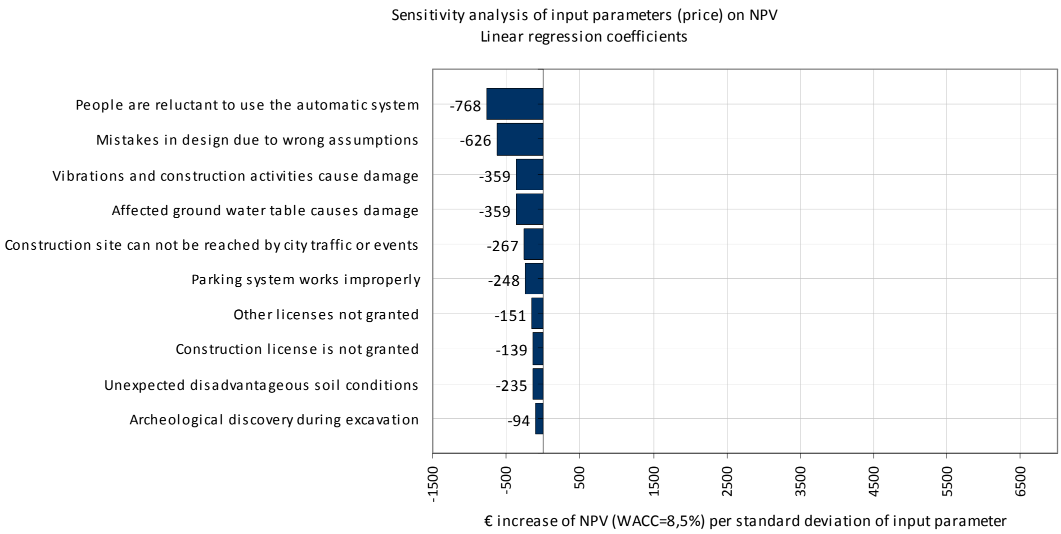


Figure 86 List of regression coefficients for risk analysis input parameters

APPENDIX VIII – VALUATION WITH DECISION TREE

VIII.1. Valuation of flexibility with a decision tree

In this section the practical case of the valuation of flexibility is discussed. In chapter 7 the theory of real option analysis using decision trees is presented. In this appendix the application of decision trees on the case study is central. The calculation continues on the hand calculation of the model as presented in appendix VI.

For the valuation of flexibility, the project in the base case is divided into seven phases. The phases are listed in table 3. The time frames are based on the base case planning. The time frame of each phase is in half years from the start of the project. These phases embrace the project activities listed in the third column of the table. All project cash flows are divided into discounted cash flows (DCF) and commercial cash flows (CCF). The CCF are assumed to be the revenues from the exploitation. The DCF are all the cash flows related to keep de construction in shape and the exploitation running. All these cash flows are discounted and grouped into these phases.

Phase	Half year	Activity
1	1st	Engineering and preparations
2	2nd – 3rd	Construction part I
3	4th – 5th	Construction part II with function specific adjustments
4	6th – 7th	Exploitation year 1
5	8th – 9th	Exploitation year 2
6	10th – 15th	Exploitation year 3-5
7	16th – end	Exploitation year 6 – end of concession

Table 57 Phases in project with time frame and phase description

The parking demand is the boundary condition that is taken as the external uncertainty value. The description of this external uncertainty value is done using five scenarios. In each scenario the occupation rate is varied.

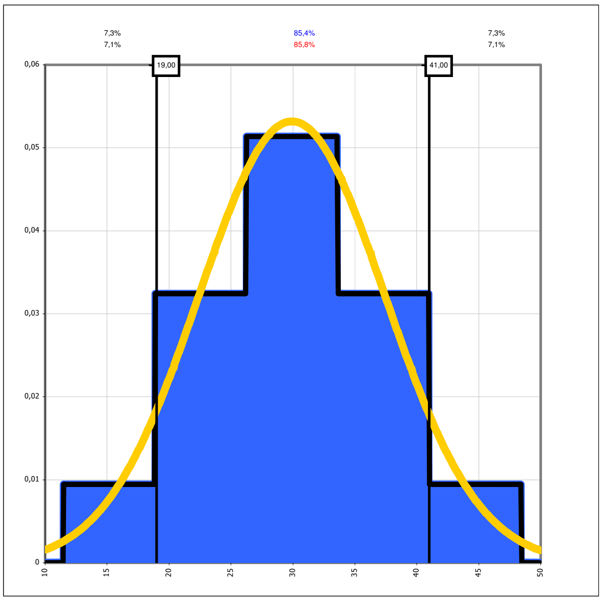


Figure 87 Approximation of normal distributed demand (yellow line) by five scenarios (five histrogram bars)

The values are based on the research for occupation rates of car parks in city centers (see appendix II) and the determination of the occupation rate done in appendix II. Based on this results the short term parking demand in the long run is assumed to have a N(35%;7,5%) distribution.
For simplicity, the occupation rate variation is assumed to include both variations in the occupation rate of the short term parking spaces as of the licensed parking spaces. So in the scenario that parking space demand is poor, both the demand for licensed spaces and short term parking spaces is poor. A 50% decrease in the number of licenses sold causes a 5% drop is the most extreme case, since the revenues from the licensed parking spaces are about 10% of that of the short term parkings spaces. Based on this assumption the parking demand is assumed to have a N(35%;10%) distribution.

The five scenarios used for the valuation of flexibility are listed in Table 58:

Demand scenario	Occupation rate	probability
Very Low	15%	7%
Below Expected	25%	24%
Expected	35%	38%
Above Expected	45%	24%
Very High	55%	7%

Table 58 Demand scenarios

VIII.2. Cases

In this research the value of flexibility is researched for two real options:

- The value of the option of developing a second similar car park
- The value of the option of switching to an alternative exploitation of the construction

In order to value the option multiple cases are modeled with decision tree analysis. The difference between the distribution of the considered option on the one side and the base case without an option on the other, gives the value of the flexibility. In this appendix the assumptions and dependencies are described for the calculation in each decision tree. The theory of the decision tree and discussion on the use of decision trees are described in chapter 7. The results are given in chapter 12. The cases that are researched in order to determine the value of the above mentioned options are:

- Base case (see VIII.2.)
- Real option of developing a second car park in phase 3 (see VIII.3.)
- Real option of developing a second car park in phase 6 (see VIII.4.)
- Real option of developing a second car park in phase 3 and 6 (see VIII.5.)
- Real option of alternate exploitation(see VIII.6.)

The decision trees used in the research are shown in this appendix. In Figure 88 the components of the decision tree are explained. In a decision node the highest of two expected values is chosen. In a chance node the value of each branch is multiplied by its probability of occurrence. The overall value of the project including the option which is considered in the tree is given at the top of the tree.

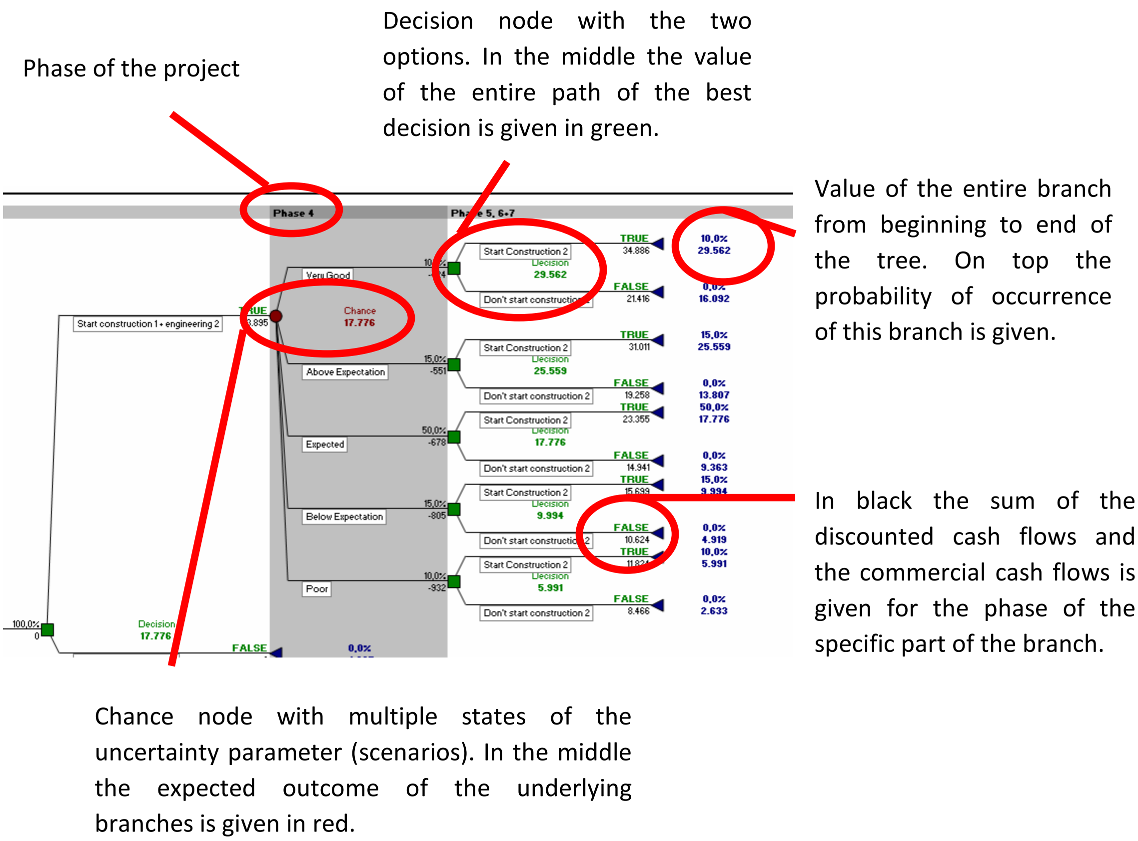


Figure 88 Graphical explanation of the used decision tees

VIII.3. Base case

In the base case of the decision tree the standard project course is put into a decision tree. Since the demand scenarios are symmetric this decision tree yields the same result as the standard NPV calculation as is done in the first section of this appendix.
In the base decision tree, the next uncertainties and decisions are included for

- Internal decision to start the project
- External uncertainty of winning the tender
- Internal decision to start the construction.
- External uncertainty in the demand by the five pre described scenarios.

The first three bullet points including the underlying assumptions are equal in all other decision trees.

The decision to start the project depends on the project valuation of the initial feasibility study, If this is large enough the engineering of the project is started. The threshold value for the NPV is in the initial study is: NPV > -€ 5.000.000.
If a portfolio of projects is considered or the expected revenues from a project in general, the uncertainty of winning the tender should be included. If only a certain percentage is won, the expected revenues drop with this percentage. This uncertainty is included in the decision tree to point out the effect of the uncertainty of winning a tender on the total expected revenues from a portfolio of projects. However in this study the project is considered as a stand alone with the assumption that the project is already won. In the other decision trees these two assumptions are not discussed further.

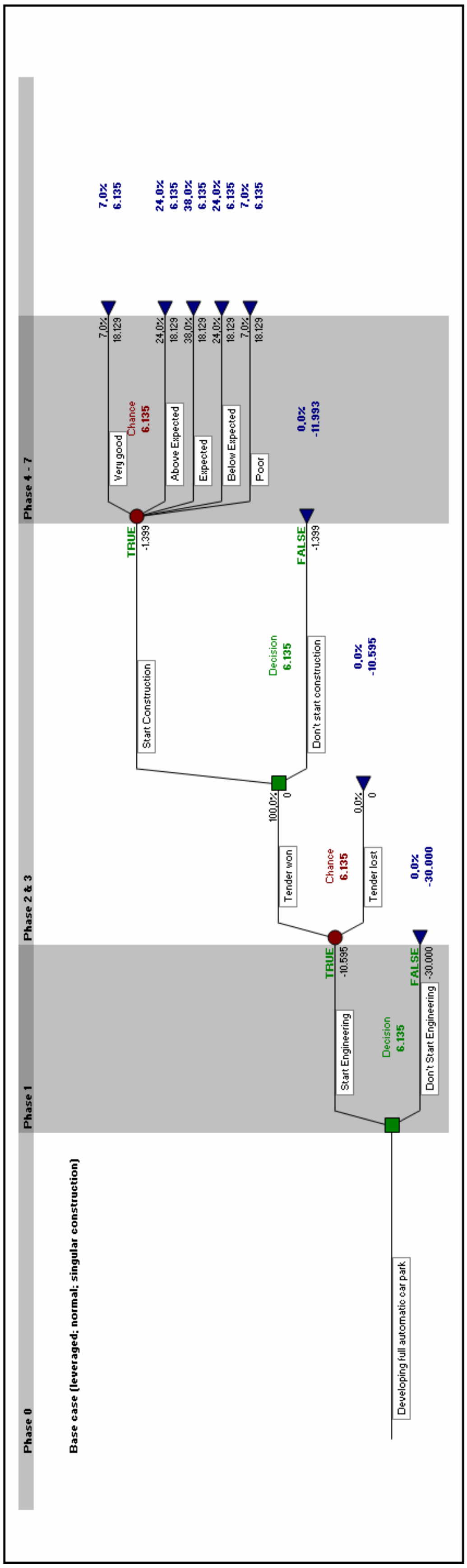


Figure 89 Decision tree of the base case of the project's course.

For the calculation next assumptions are made:

Point in decision tree	Phasing	Assumption	Values at branch
Decision to start further engineering	Start phase 0	See introduction base case VIII.2	DCF and CCF of phase 1
Uncertainty of winning tender	Start phase 2	See introduction base case VIII.2	Ptender won=100% Ptender lost=0%
Decision to start construction	Start phase 2	Construction starts if the NPV of the branch "start construction" is larger than "don't start construction"	DCF and CCF of phase 2 & 3
Uncertainty by demand scenarios	Start phase 4	Scenarios in Table 58	Probabilities according to scenarios DCF and CCF of phase 4 – 7, according to scenarios

Table 59 Assumptions in the base case decision tree

VIII.4. Real option of developing a second car park in phase 3

If the construction and exploitation of the first car park turns out to be profitable, a second similar car park could be developed on a second location nearby. If the first car park is constructed, the expectation is that it will be profitable. For this reason the engineering of the second car park commences when the construction of the first car park is started. After one year of exploitation a decision point is included on which can be chosen to execute the option of the second car park depending on the success of the first car park.

The cash flows of the second car park are the same as the first car park, however discounted from a different phase. No extra advantages due to learning or scale effects are taken into account. The costs of the engineering of car park 2 are discounted from phase 2. The construction costs of the second car park are discounted from phase 5. Assumed is that if the first car park is in a specific scenario, the cash flows of the second car park are according to the same scenario.

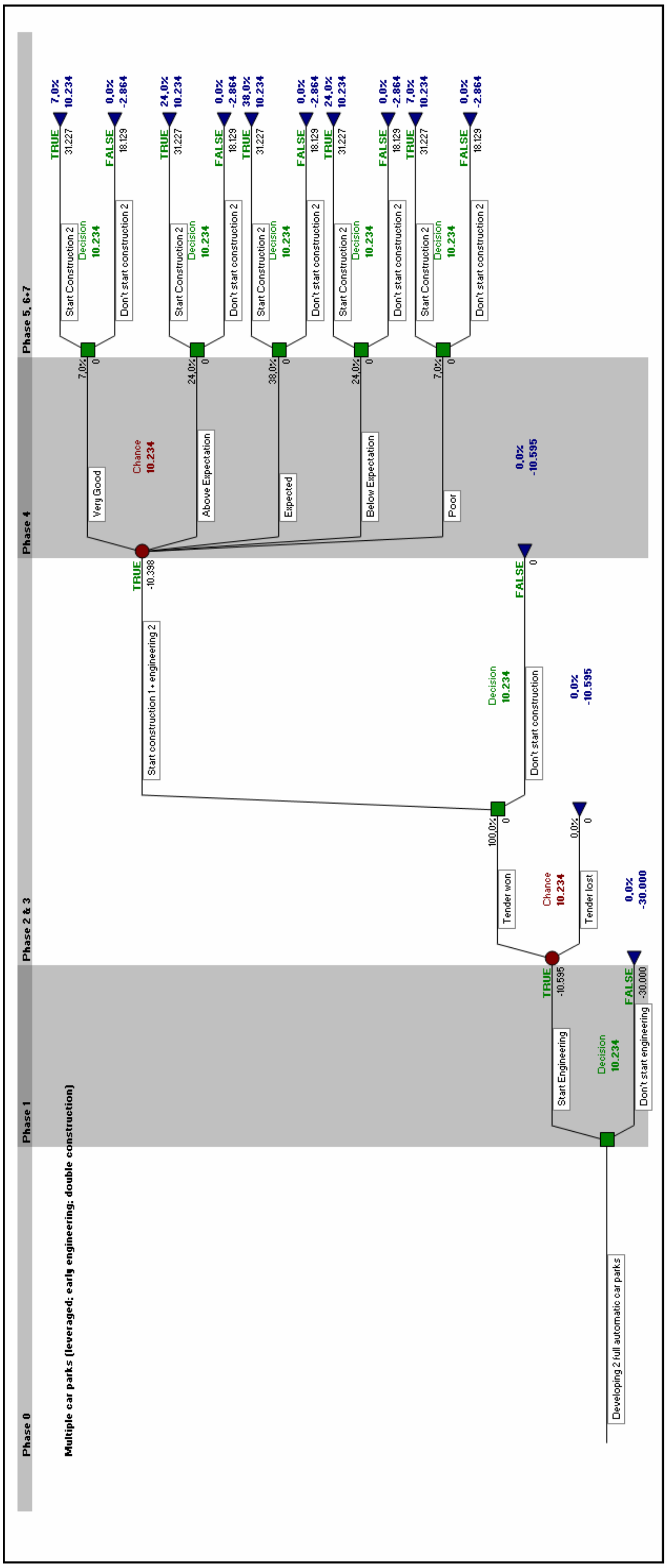


Figure 90 Case development of 2nd car park in which the engineering of car park 2 starts in phase 3 of the first car park. Construction of the 2nd car park starts in phase 5.

Point in decision tree	Phasing	Assumption	Values at branch
Decision to start further engineering	Start phase 0	See introduction base case VIII.2	DCF and CCF of phase 1
Uncertainty of winning tender	Start phase 2	See introduction base case VIII.2	Ptender won=100%; Ptender lost=0%
Decision to start construction and start engineering of second car park	Start phase 2	Construction and engineering of the second car park starts if the NPV of the branch "start construction + engineering 2" is larger than "don't start construction"	• DCF and CCF of phase 2 & 3 of car park 1 • DCF and CCF of phase 1 of car park 2
Uncertainty by demand scenarios	Start phase 4	Scenarios in Table 58	Probabilities according to scenarios; DCF and CCF of phase 4 pf car park 1 according to scenarios
Decision to start construction second car park	Start phase 5	Construction of the second car park is started if the NPV of the branch including the construction of the second car park is higher than without the construction of the second car park.	Branch incl construction car park 2 • DCF and CCF of phase 5-7 of car park 1 according to scenario • DCF and CCF of phase 2 – 7 of car park 2 according to scenario Branch excl construction car park 2 • DCF and CCF of phase 5-7 of car park 1 according to scenario

Table 60 Assumptions in case of development of second car park

VIII.5. Real option of developing a second car park in phase 6

This decision tree is similar to the one in the previous section and includes the option of developing a second car park if the construction and demand for car parks turns out to be advantageous. The difference with the tree in the previous section is that the complete development (including engineering) of the second car parks starts after two years exploitation of the first car park. The cash flows of the second car park are identical of those of the first car park, however discounted back from the start of phase 6. Assumed is that if the first car park is in a specific scenario, the cash flows of the second car park are according to the same scenario.

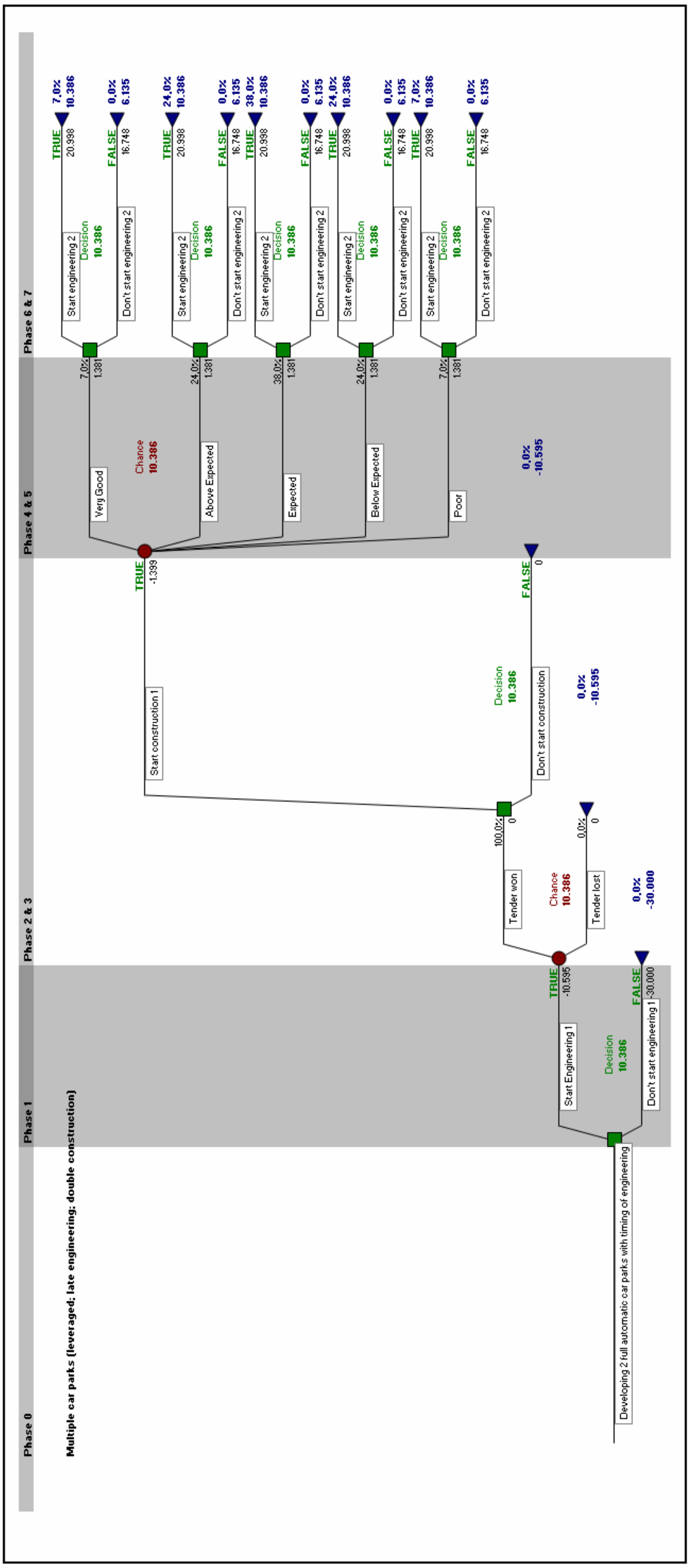


Figure 91 Case development of 2nd car park in which the engineering starts in phase 6 of the first car park.

Point in decision tree	Phasing	Assumption	Values at branch
Decision to start further engineering	Start phase 0	See introduction base case VIII.2	DCF and CCF of phase 1
Uncertainty of winning tender	Start phase 2	See introduction base case VIII.2	Ptender won=100%; Ptender lost=0%
Decision to start construction and start engineering of second car park	Start phase 2	Construction of the first car park starts if the NPV of the branch "start construction" is larger than "don't start construction"	• DCF and CCF of phase 2 & 3 of car park 1
Uncertainty by demand scenarios	Start phase 4	Scenarios in Table 58	Probabilities according to scenarios; DCF and CCF of phase 4&5 of car park 1 according to scenarios
Decision to start construction second car park	Start phase 6	Development of the second car park is started if the NPV of the branch including the complete development of the second car park is higher than without the development of the second car park.	Branch incl development car park 2 • DCF and CCF of phase 6-7 of car park 1 according to scenario • DCF and CCF of phase 1 – 7 of car park 2 according to scenario Branch excl development car park 2 • DCF and CCF of phase 6-7 of car park 1 according to scenario

Table 61 Assumptions in case of development of second car park after two years exploitation

VIII.6. Real option of developing a second car park in phase 3 and 6

This decision tree treats the option to choose later in the project to develop a second car park. This tree includes both the options to start the engineering of the second car park in phase 3 or phase 6. This is a combination of the two above real options. All the assumptions and values in the tree are the same as in the previous decision trees. For these assumptions one is referred to section IX.2 and IX.3 of this appendix.

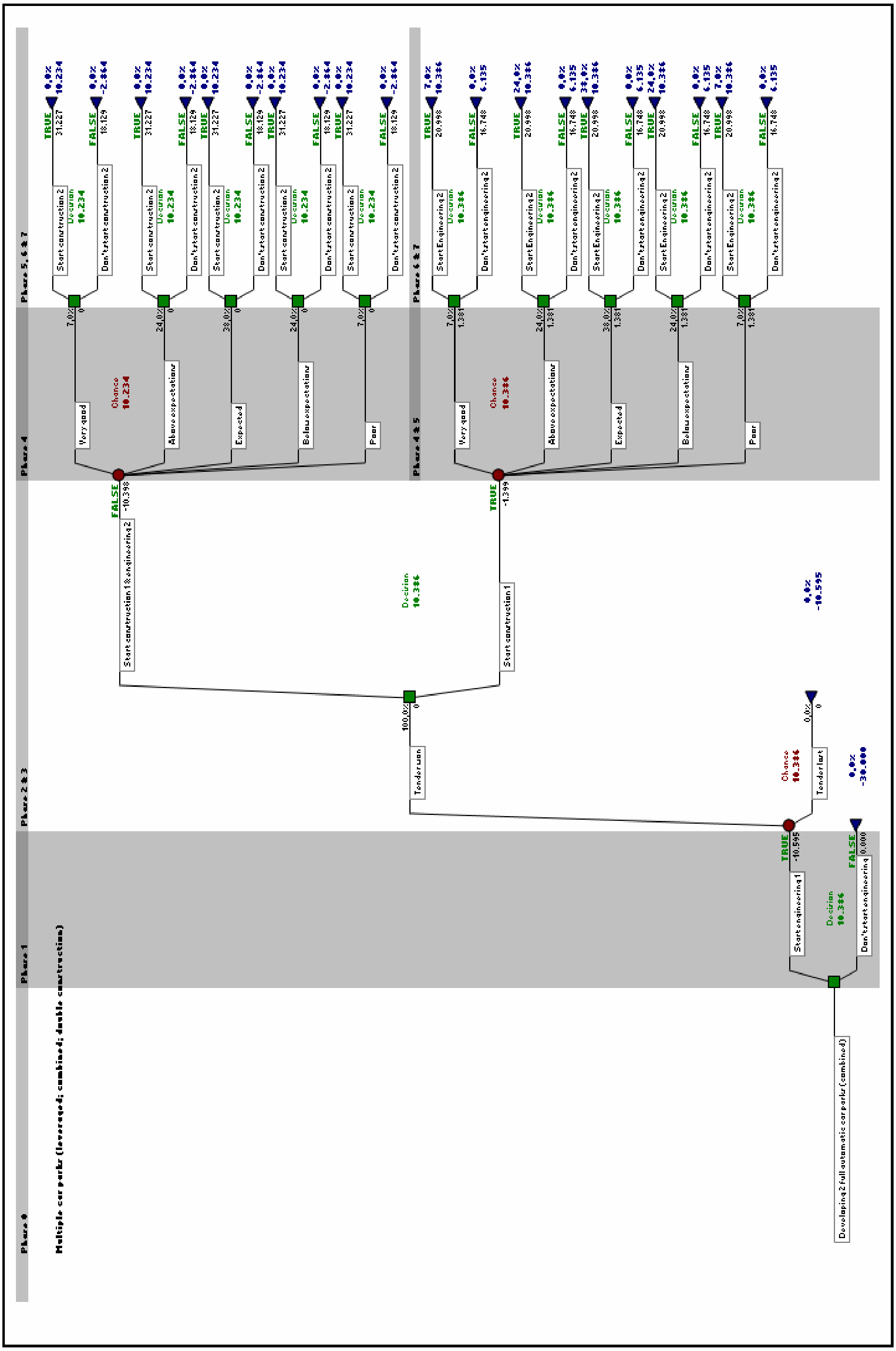


Figure 92 Case development of 2nd car park with both the option of starting the development of the second car park in phase 3 and 6

VIII.7. Real option of alternative exploitation

This decision tree treats the option of switching the sort of exploitation of the construction. If the demand for parking turns out to be not profitable, the exploitation could switch to alternative ways of exploitation. Next to general fluctuation in parking demand this can also be caused by a changing parking policy by the city of Amsterdam. For this reason an additional external uncertainty is included in the decision tree. The probability of unfavorable changes in the policy is not researched further. Therefore the probability of unfavorable changes is set to 0%. However the influence of this uncertainty should not be overseen.

The option central in this decision tree is an option to choose exploitation after two years of exploitation as a car park. At this point there is the option to switch exploitation or to continue of the exploitation as a car park. The description of alternative exploitation is described in chapter 10. A possible alternative exploitation would be an automatic self storage business. Below the calculation of the revenues generated by the alternative exploitation are given.

Point in decision tree	Phasing	Assumption	Values at branch
Decision to start further engineering	Start phase 0	See introduction base case VIII.2	DCF and CCF of phase 1
Uncertainty of winning tender	Start phase 2	See introduction base case VIII.2	Ptender won=100%; Ptender lost=0%
Decision to start construction of first car park	Start phase 2	Construction of the first car park starts if the NPV of the branch "start construction" is larger than "don't start construction"	• DCF and CCF of phase 2 of car park 1
Uncertainty of parking policy	Start phase 3	See introduction VIII.5	Pfavourable =100%; Pnot favourable=0%
Decision to develop construction as car park or as alternate exploitation	Start phase 3	Exploitation as a car park is chosen if the NPV of the car park exploitation is higher than the NPV of the alternative exploitation. In the NPV of the alternative exploitation no switching costs or costs for a fully automated car park is included.	Branch car park exploitation • DCF and CCF of phase 3 of car park 1 Branch alternative exploitation • DCF and CCF of phase 3-7 of alternative exploitation
Uncertainty by demand scenarios	Start phase 4	Scenarios in Table 58 for year 1 and 2 of exploitation	• DCF and CCF of phase 4 & 5 of car park 1 according to scenarios
Decision to exploit construction as car park or as alternate exploitation	Start phase 6	Switching in the exploitation at this phase is done if the NPV of the alternative exploitation combined with the NPV of the switching costs and the revenues from selling the parking system is larger than the NPV of continuing the exploitation as a car park.	Branch car park exploitation • DCF and CCF of phase 6 & 7 of car park 1 according to scenario Branch alternative exploitation • DCF and CCF of phase 6 & 7 of alternative exploitation • Discounted switching costs • Discounted revenues from selling parking system.

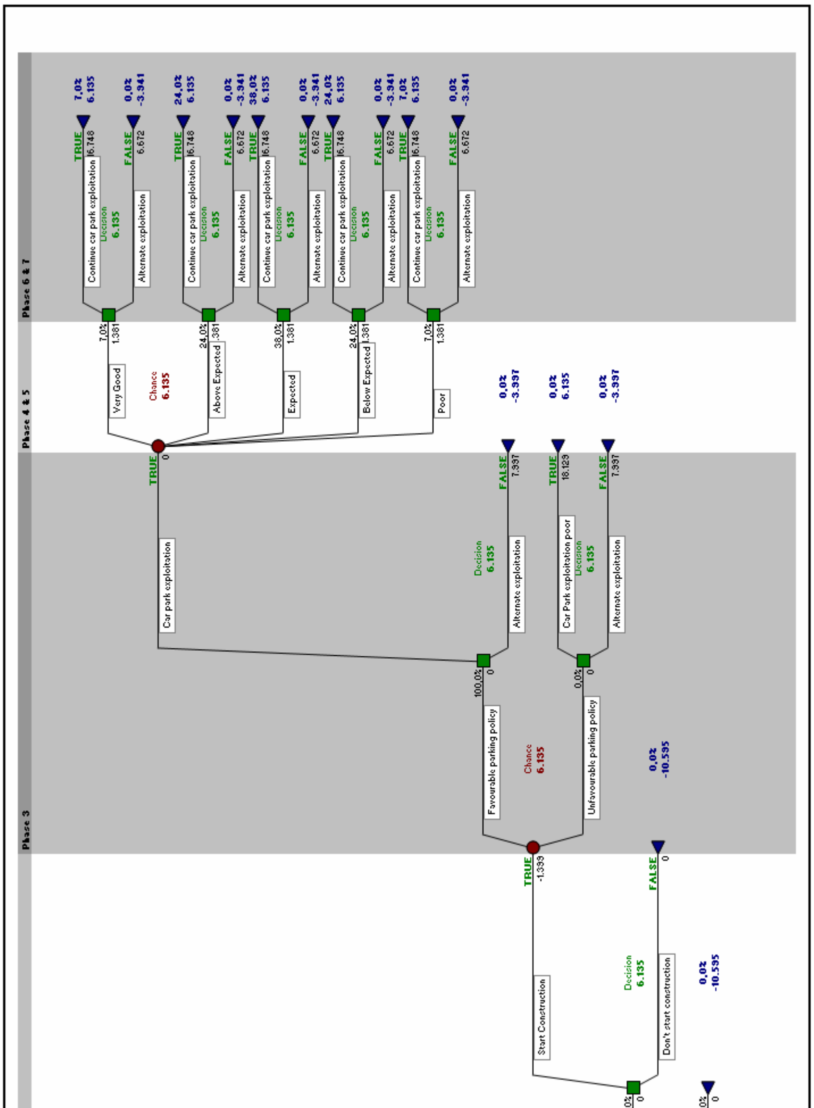


Figure 93 Case with alternating exploitation of the construction.

The underlying assumptions for the revenues of the alternative exploitation are:

$$p_{m^3\ selfstorage} = 20\ €/m^3\ /month$$
$$h_{other\ floors} = 2{,}2\ m$$
$$p_{m^2\ selfstorage} = 44\ €/m^2\ /month$$
$$occupation\ rate_{average} = 85\%$$
$$occupation\ rate_{worst\ case;\ 95\%} = 65\%$$

$$p_{m^2\ selfstorage} = 450\ €/m^2$$
$$p_{m^2\ selfstorage\ worst\ case;95\%} = 350\ €/m^2$$
$$\sigma = 50€/m^2$$

Revenue from selling parking system : 80% of initial costs parking system
One time switching costs to alternate exploitation = €1.000.000

APPENDIX IX – VALUATION WITH BINOMIAL TREE

IX.1. Valuation of flexibility with binomial tree

In this section the practical case of the valuation of flexibility with a binomial tree is discussed. In chapter 7 the theory of real option analysis using binomial trees is presented. In this appendix the application of binomial trees on the case study is central. The calculation continues on the hand calculation of the model as presented in appendix VI.

Analogue with the valuation of flexibility with decision trees, the project in the base case is divided into seven phases for the valuation using a binomial tree. The phases are listed in table 3. The time frames are based on the base case planning. The time frame of each phase is in half years from the start of the project. These phases embrace the project activities listed in the third column of the table. In the forth column the value of theta gives the conditional probability to proceed to that phase from the previous one. All project cash flows are divided into discounted cash flows (DCF) and commercial cash flows (CCF). The CCF are assumed to be the revenues from the exploitation. The DCF are all the cash flows related to keep de construction in shape and the exploitation running. All these cash flows are discounted and grouped into these phases.

Phase	Half year	Activity	Theta
1	1st	Engineering and preparations	1,0
2	2nd – 3rd	Construction part I	1,0
3	4th – 5th	Construction part II with function specific adjustments	1,0
4	6th – 7th	Exploitation year 1	1,0
5	8th – 9th	Exploitation year 2	1,0
6	10th – 15th	Exploitation year 3-5	1,0
7	16th – end	Exploitation year 6 – end of concession	1,0

Table 62 Phases in project with time frame and phase description

The parking demand is the boundary condition that is taken as the external uncertainty value. The description of this external uncertainty value is done using five scenarios. In each scenario the occupation rate is varied.

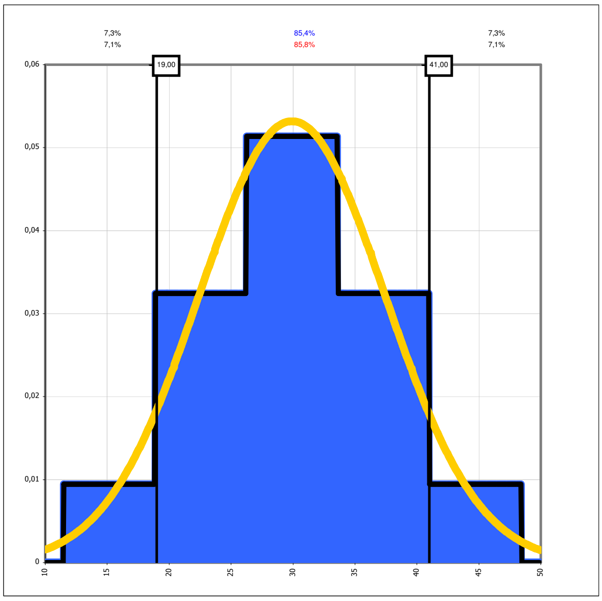


Figure 94 Approximation of normal distributed demand (yellow line)

by five scenarios (five histrogram bars)

The values are based on the research for occupation rates of car parks in city centers (see appendix II) and the determination of the occupation rate done in this appendix as well. Based on this results the short term parking demand in the long run is assumed to have a N(35%;10%) distribution. For the derivation of the occupation rate distribution one is referred to the introduction of appendix VIII.

The five scenarios used for the valuation of flexibility are listed in Table 58:

Demand scenario	Occupation rate	probability
Very Low	15%	7%
Below Expected	25%	24%
Expected	35%	38%
Above Expected	45%	24%
Very High	55%	7%

Table 63 Demand scenarios

IX.2. Cases

In this research the value of flexibility with binomial tree is researched for two real options:

- The value of the option of developing a second similar car park
- The value of the option of switching to an alternative exploitation of the construction

In order to value the option multiple cases are modeled with binomial trees. The difference between the distribution of the considered option on the one side and the base case without an option on the other, gives the value of the flexibility. In this appendix the assumptions and dependencies are described for the calculation in each decision tree. The theory of the binomial tree and discussion on the use of binomial trees is described in chapter 7. The results are given in chapter 12. The cases that are researched in order to determine the value of the above mentioned options are:

- Base case (see IX.3.)
- Real option of developing a second car park in phase 3 (see IX.4.)
- Real option of alternate exploitation(see IX.5.)

IX.3. Base Case

To valuate a project using a binomial tree first the tree with possible outcomes of the commercial cash flows (CCF) has to be constructed. The theory of the binomial trees is described in chapter 7. In the base case the asset value is determined by the expected discounted cash flows in phase 4 until 7. The CCF of each scenario is multiplied by the probability of occurrence of the scenario. Adding these over all the phases results in the asset value of the CCF. In order to determine the volatility of the cash flows, the CCF of phase 4-7 of the very good demand scenario is divided by the asset value. The volatility per period can then be determined.

$$A = Asset\ Value = \sum_{i=poor\ scenario}^{very\ goo\ scenario} p_i \ * (CCF_{phase\ 4\text{-}7;scenario\ i})$$

$$h = Maximum\ CCF = (CCF_{4verygood} + CCF_{5verygood} + CCF_{6verygood} + CCF_{7verygood})*(1+\frac{8,5}{100})^{2,5}$$

$$\sigma = ln(\frac{h}{A})^{(\frac{1}{2}*l)}$$

In this model dt=0,5 years. Then the multiplication for up and down can be calculated.

$$U = e^{\sigma\sqrt{dt}}$$

$$D = \frac{1}{U}$$

For the discount rates the next values are assumed.

$r_{commercial}$=8,5%

$r_{discount}$=8,5%

In the bottom three the discounted cash flows are subtracted at the beginning of the phase. For the probability of going through to the next phase, theta, the values are given in the table above.

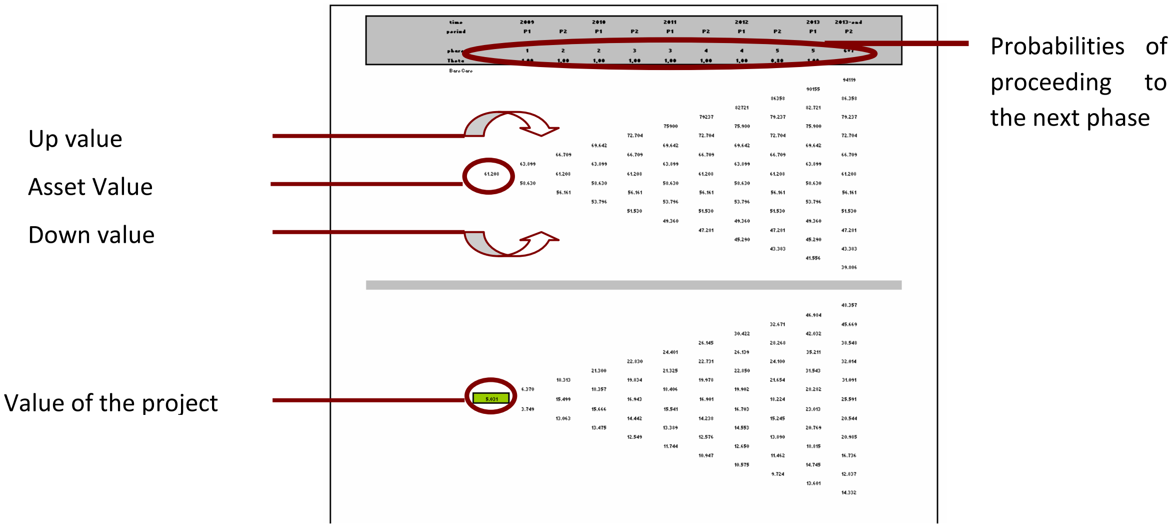


Figure 95 Components of the binomial tree

IX.2. Binomial tree of developing a second car park in phase 3

In the base case the calculation with a binomial tree was repeated and shown graphically. In this section only the differences to that case are described. The real option of developing a second car park in phase 3 in described in chapter 8 and in appendix VIII.

The asset value is determined by adding the expected cash flows of the two car parks. The maximum cash flow is determined by the cash flows in the very good exploitation scenario. In the lower tree the the discounted cash flows of the expenditures is subtracted. In the bottom of the lower tree the cash flows of only 1 car park are considered if the expected net present value is below zero.

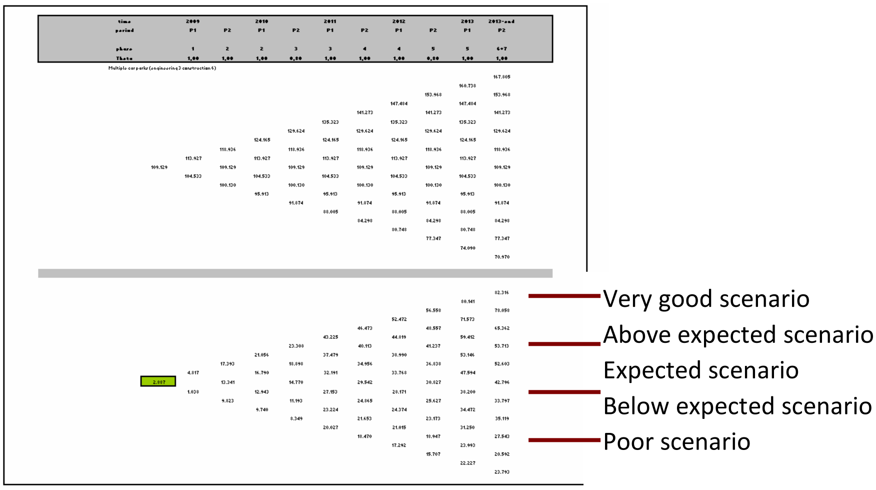


Figure 96 Distribution of scenarios over the binomial tree

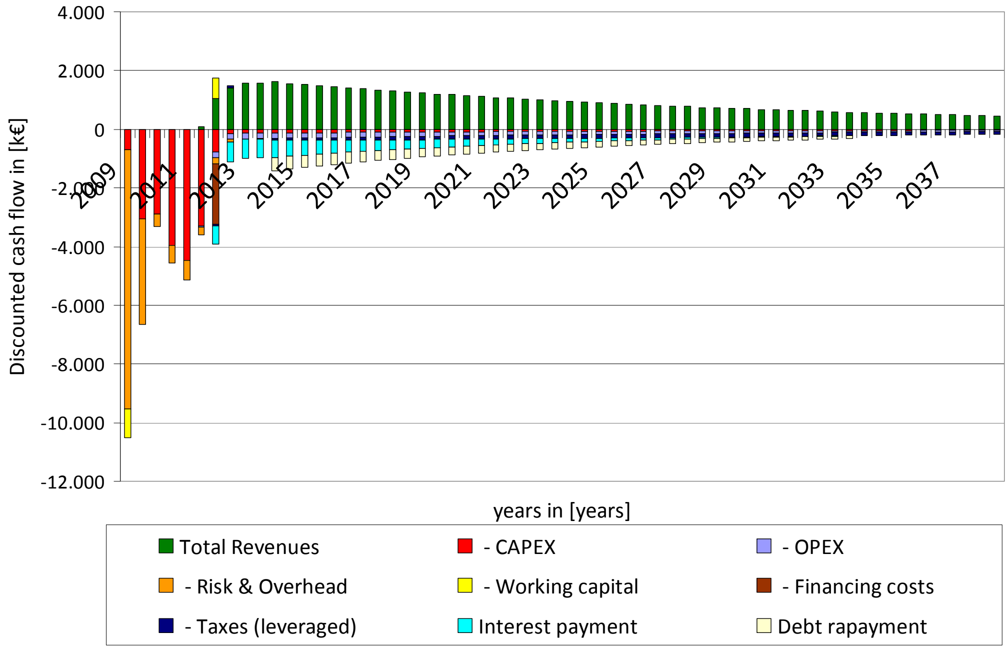
IX.3. Binomial tree of alternate exploitation

In the binomial tree the asset value is determined by the exploitation have the highest expected NPV. In the poor success scenario for example the expected NPV of a car park exploitation is lower than that of the alternative exploitation. In that case the NPV of the alternative exploitation is included in the calculation

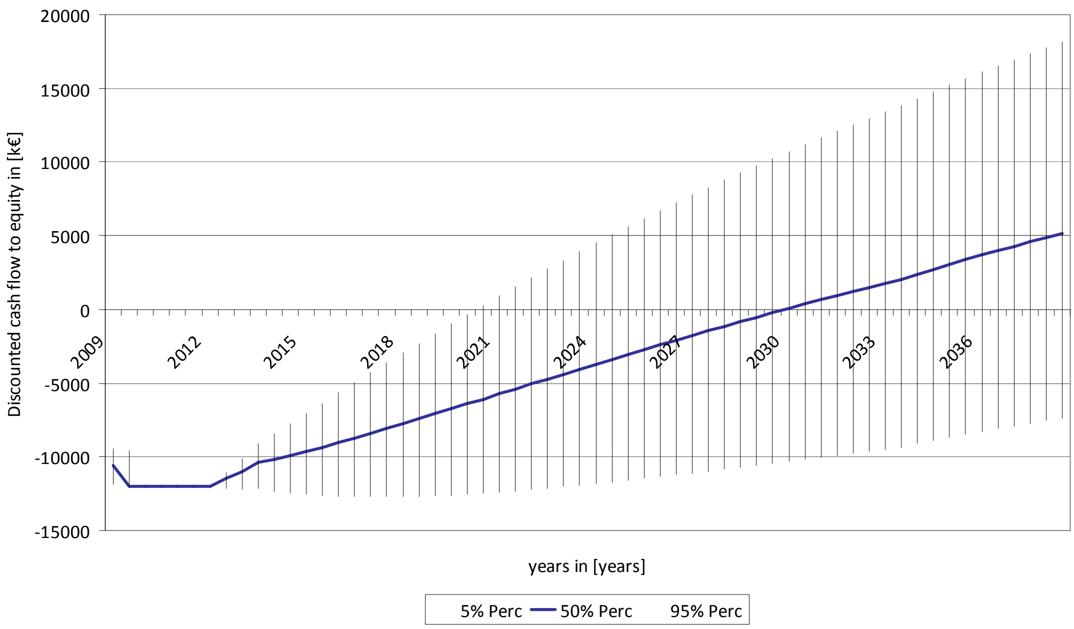
APPENDIX X – RESULTS BASE CASE

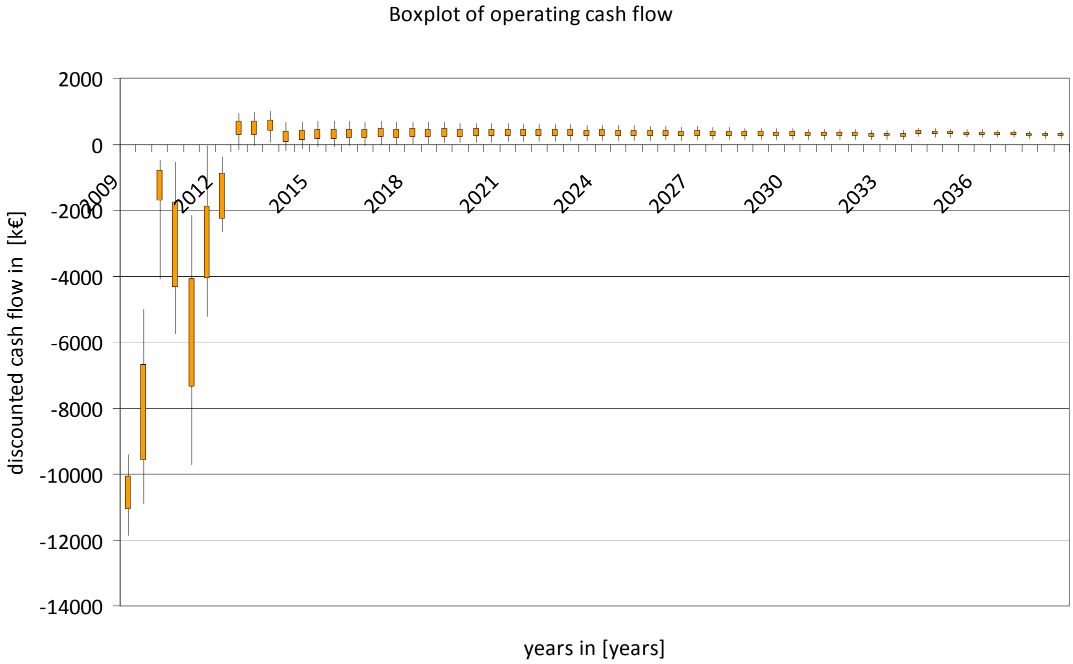
Project life: 30 years
Discount factor: 8,5%
Number of floors: 3
Correlation between costs post: enabled
Financing: 41.000 k€
Number of simulations: 10.000
Number of spaces = 464
Discounted Cash

Discounted cash flow (WACC=8,5%)

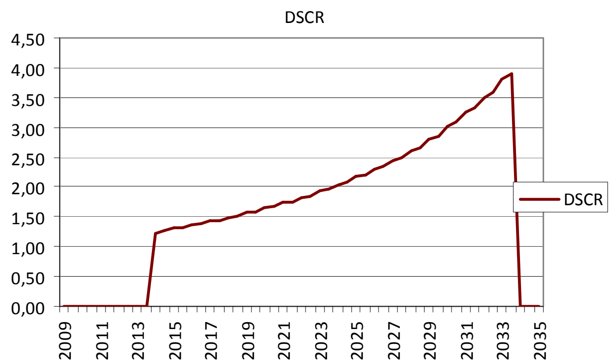


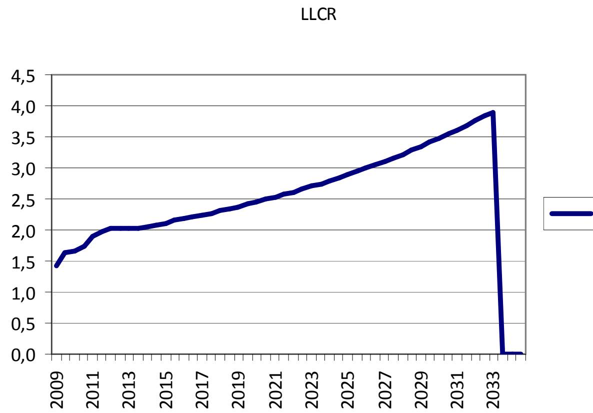
Cumulative cash flow to equity



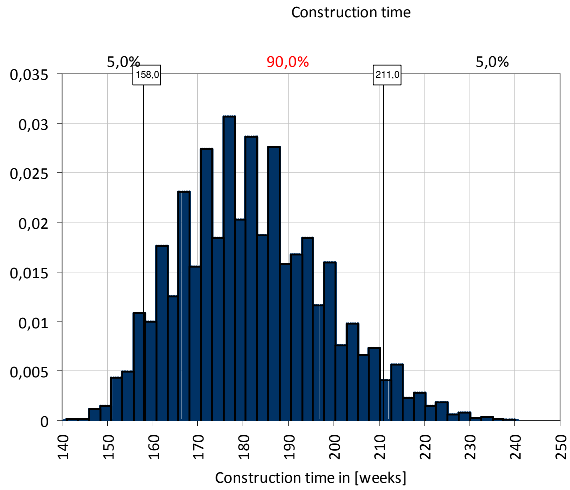


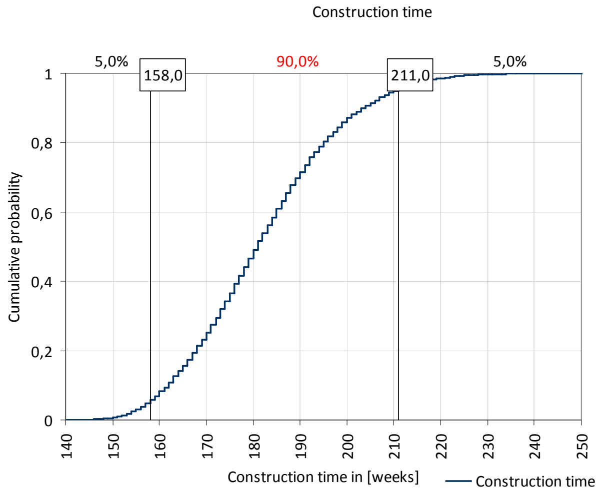
Debt Service Cover Ratio and Life Loan Cover Ratio





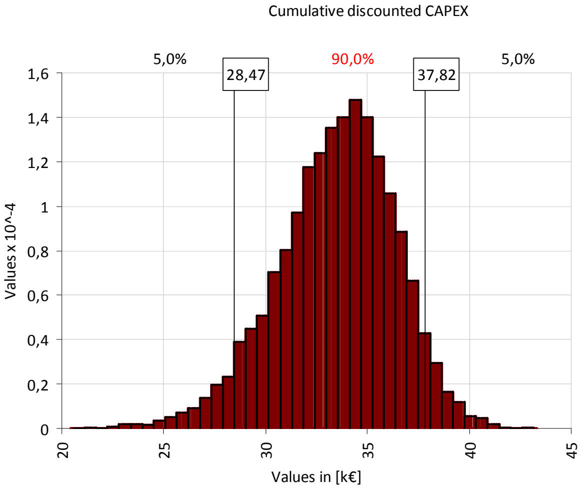
Construction time

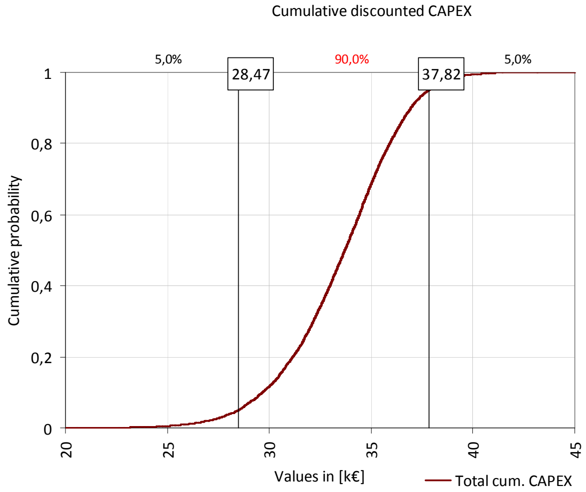




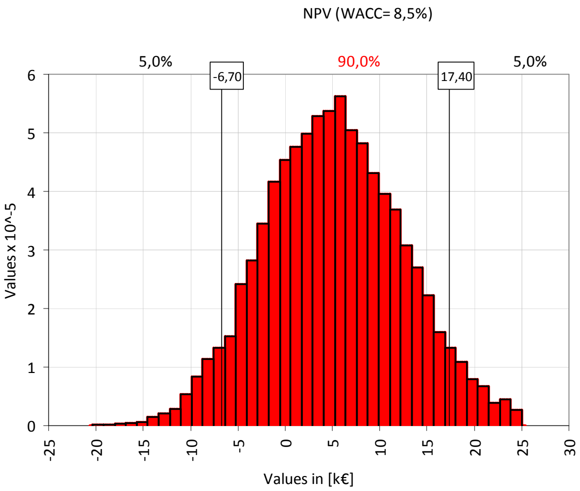
Cumulative CAPEX

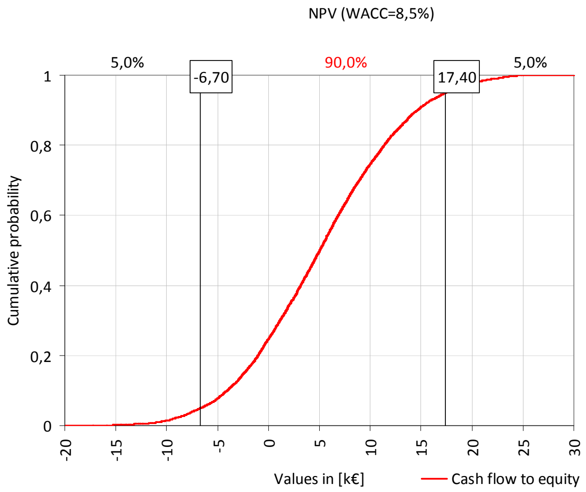
= Capex + Risk + Overhead+ Capitalized Expenses (financing costs)





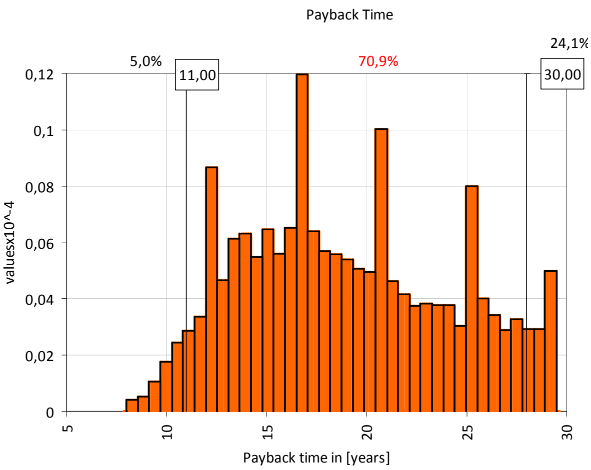
NPV at 8,5%

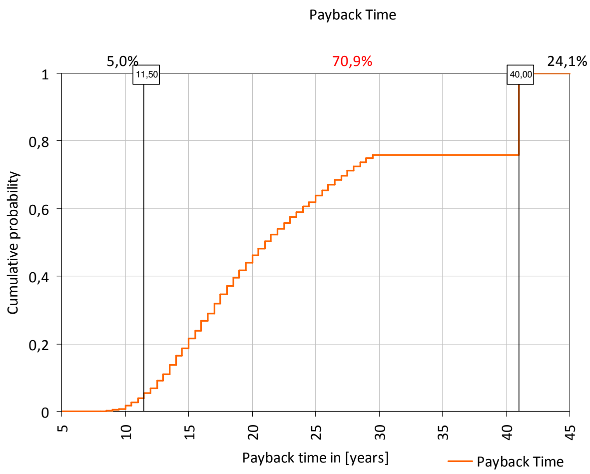




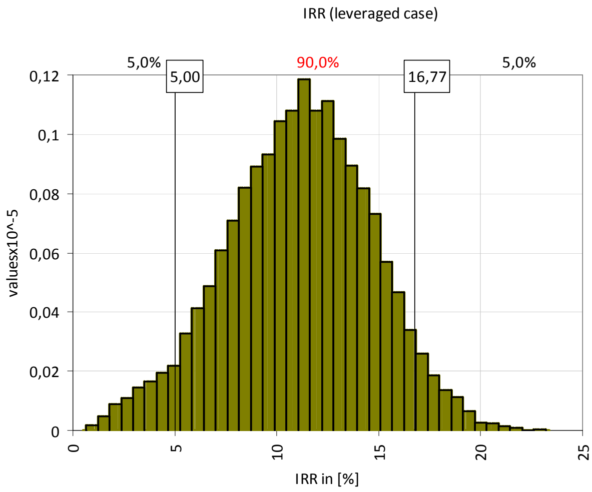
Payback period

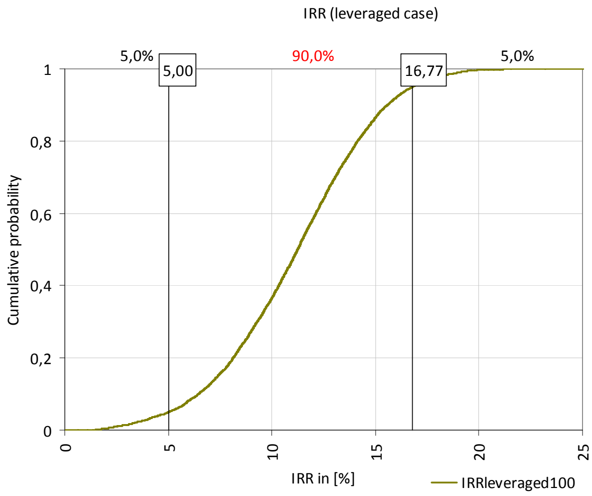
Payback times that fall beyond the project life are plotted as payback times > 40 years.



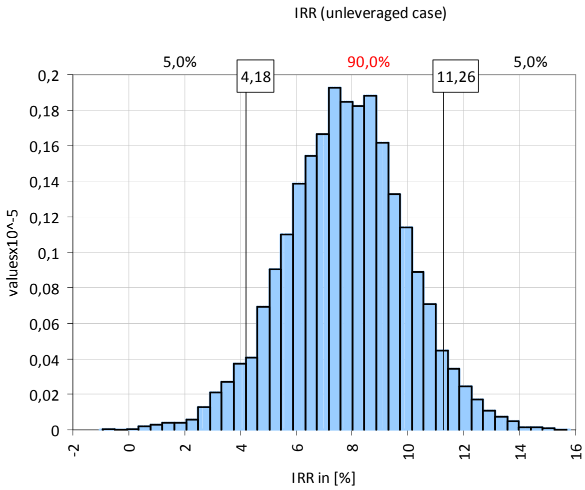


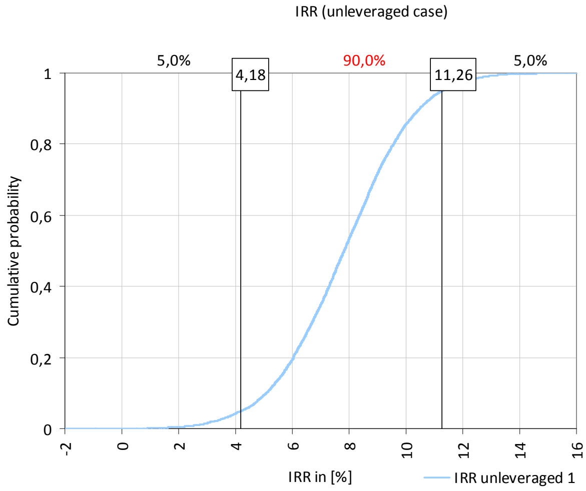
IRR leveraged case



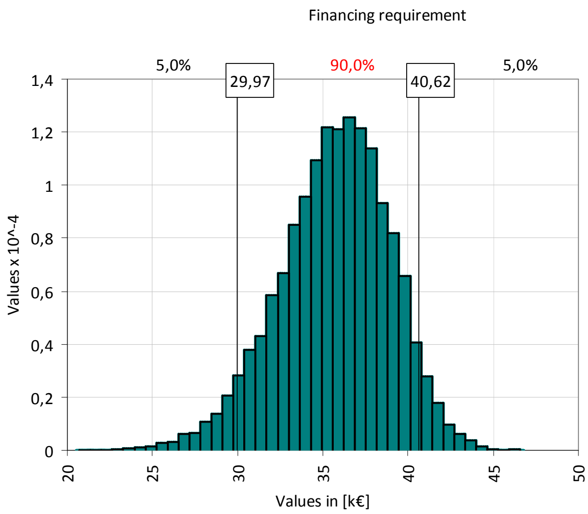


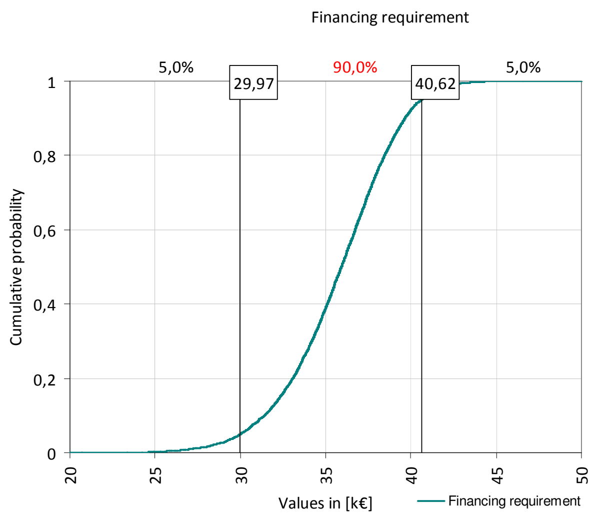
IRR unleveraged case



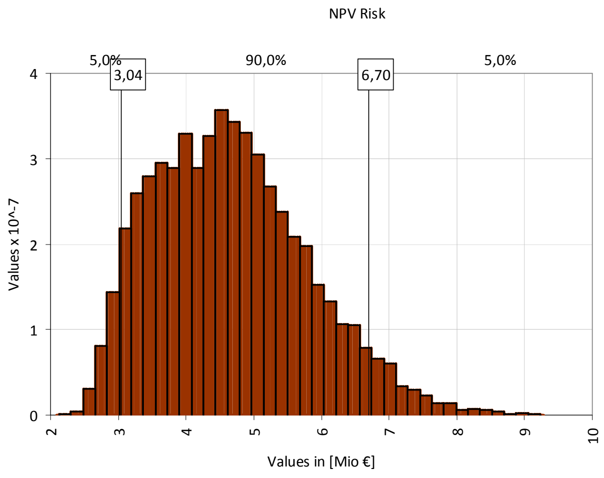


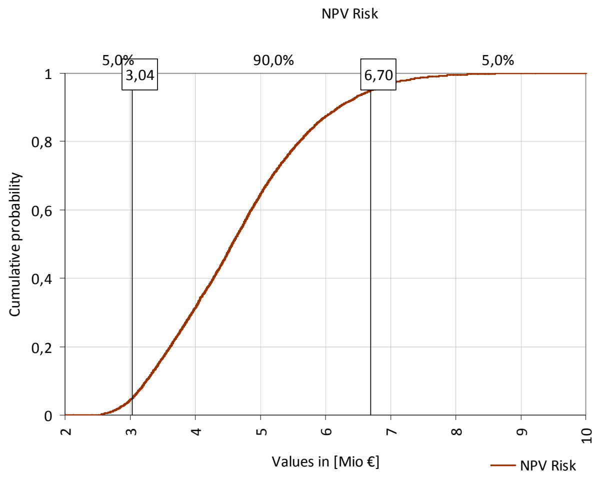
Financing reservation





Risk

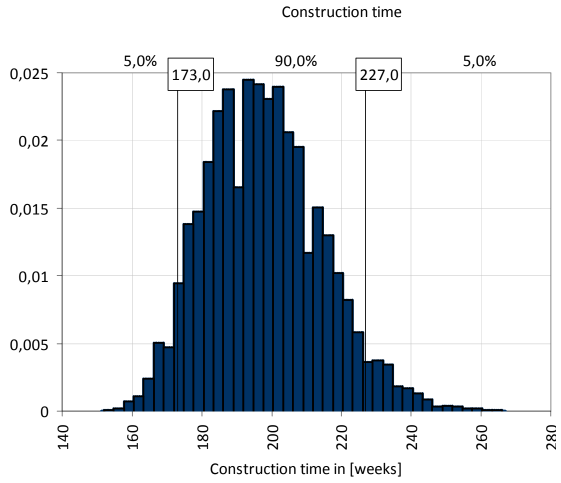

NPV Risk
5,0%
90,0%
5,0%
3,04
6,70
Values x 10^-7
Values in [Mio €]
0
1
2
3
4
2
3
4
5
6
7
8
9
10

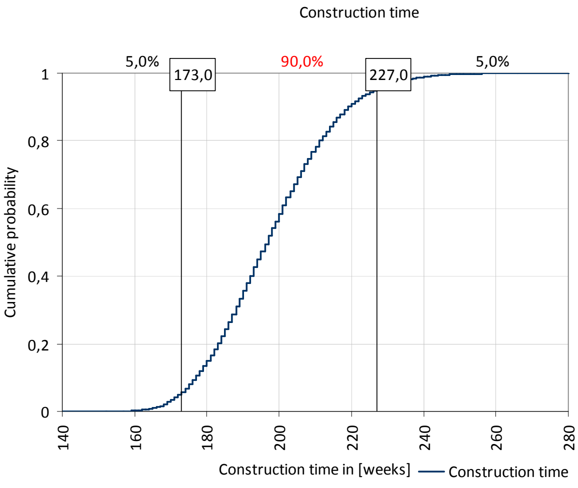

NPV Risk
5,0%
90,0%
5,0%
3,04
6,70
Cumulative probability
Values in [Mio €]
0
0,2
0,4
0,6
0,8
1
2
3
4
5
6
7
8
9
10
NPV Risk

APPENDIX XI – RESULTS 4 STOREY CAR PARK

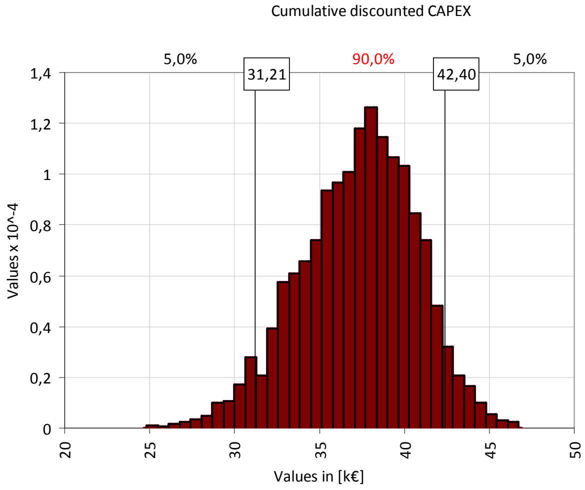
Project life: 30 years
Discount factor: 8,5%
Number of floors: 4
Correlation between costs post: enabled
Financing: 48.000 k€
Number of spaces = 610
Number of simulations: 10.000

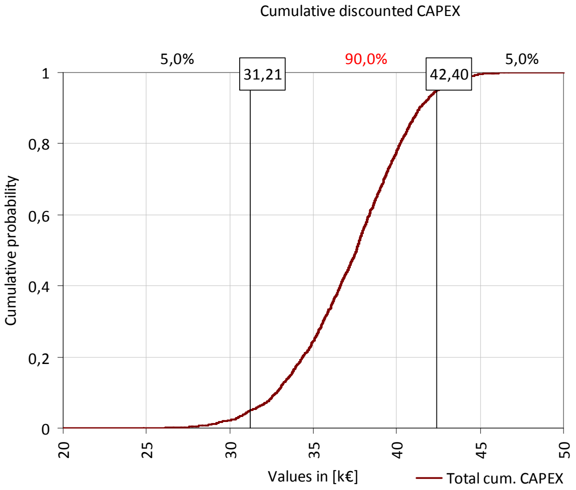
Construction time



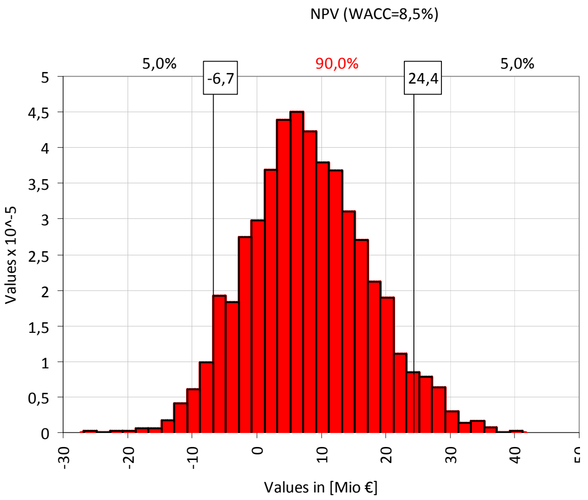


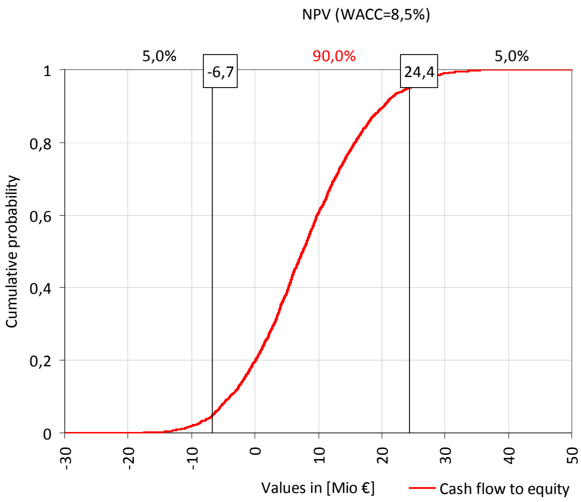
Cumulative CAPEX



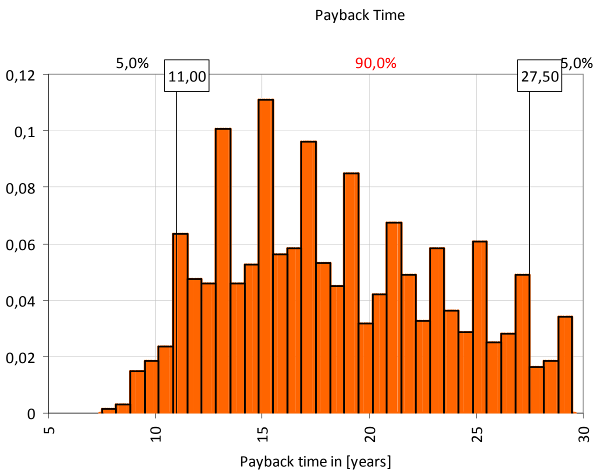


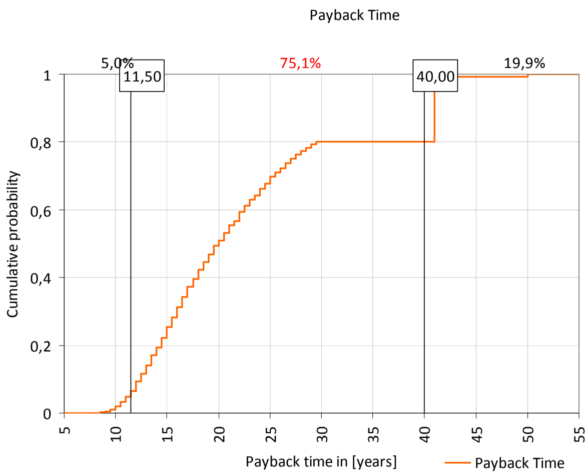
NPV at discount rate of 8,5%



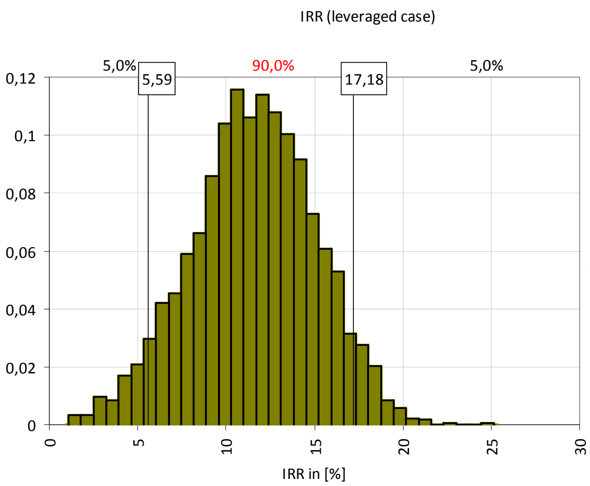


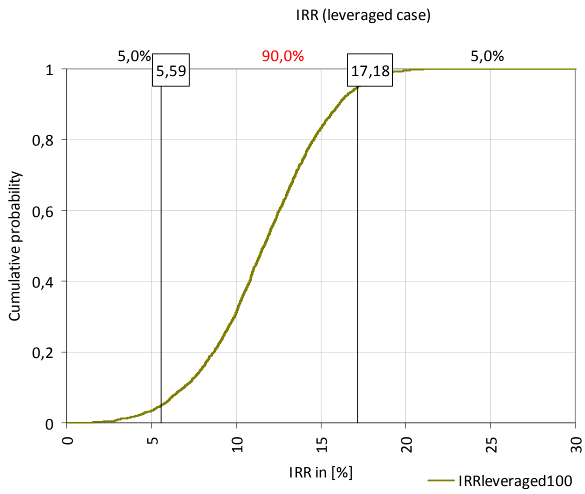
Payback



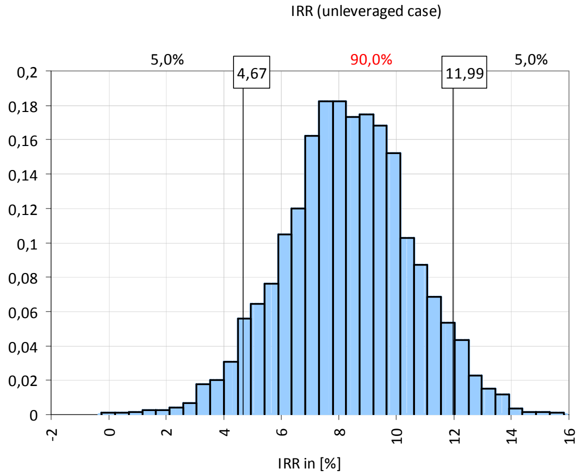


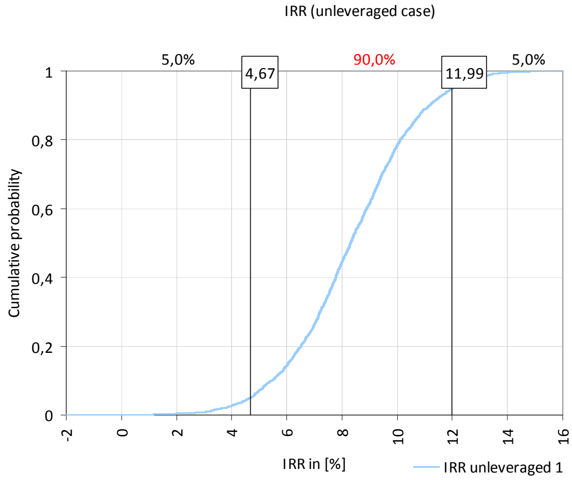
IRR leveraged case



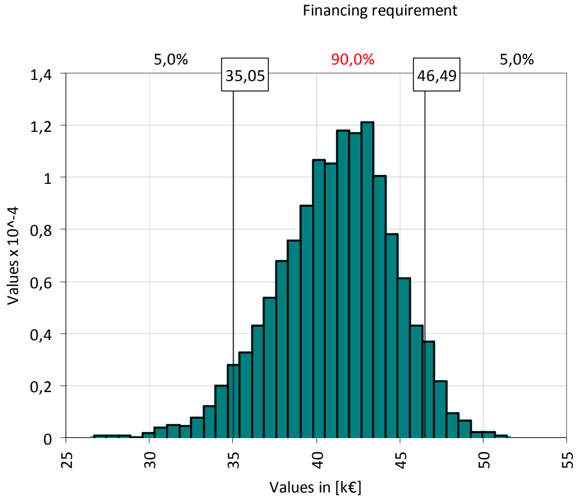


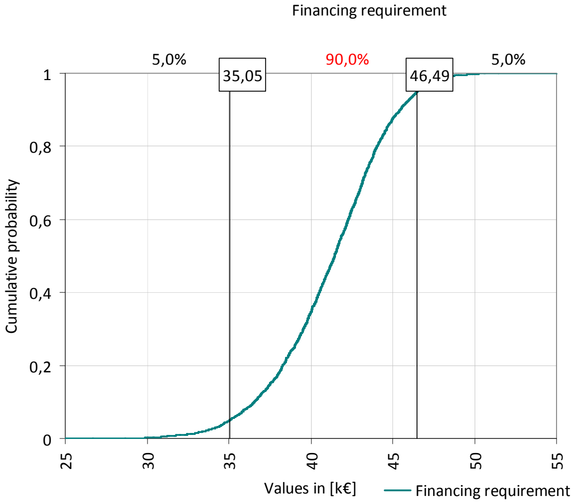
IRR unleveraged case



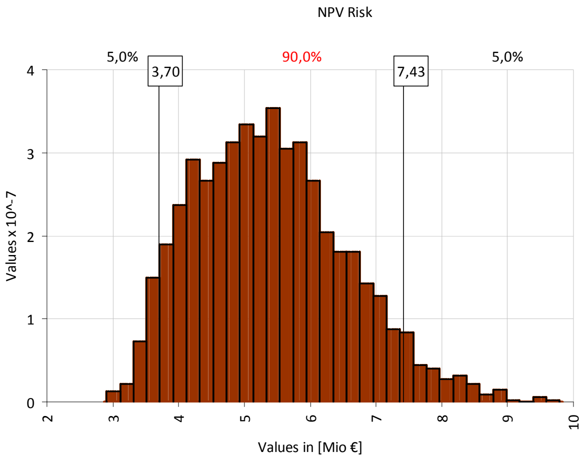


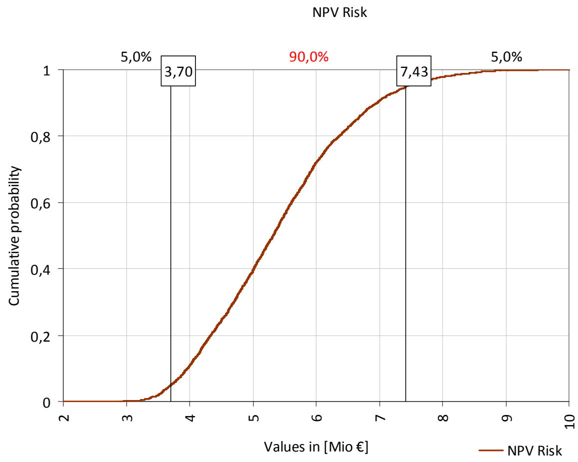
Financing reservation





Risk





APPENDIX XII – MODEL MANUAL

Main part of the research was the financial and probabilistic model developed for the valuation of of projects and exploitation. In this model the technical side of the project and the financial side are combined in order to be able to be able to determine if the project yield enough return on the invested capital. The model developed in this study is a framwork for valuation of civil engineering projects.

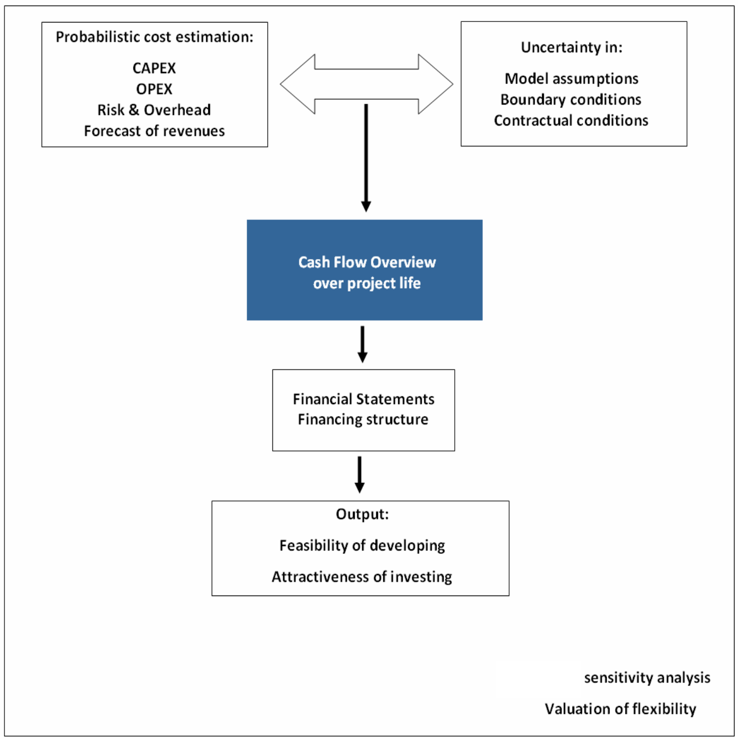


Figure 97 Setup of model

The setup of the model is shown graphically in
Figure 97. The project parameters for the CAPEX, OPEX, risk & Overhead and the revenues are the cash flows which have to be modelled to all actors in a civil engineering project. Together with the model assumptions and the boundary conditions this results in the cash flow overview over the project life. After the operating cash flows are determined, the effect of the financing and the other parameters of the net financial results can be determined.

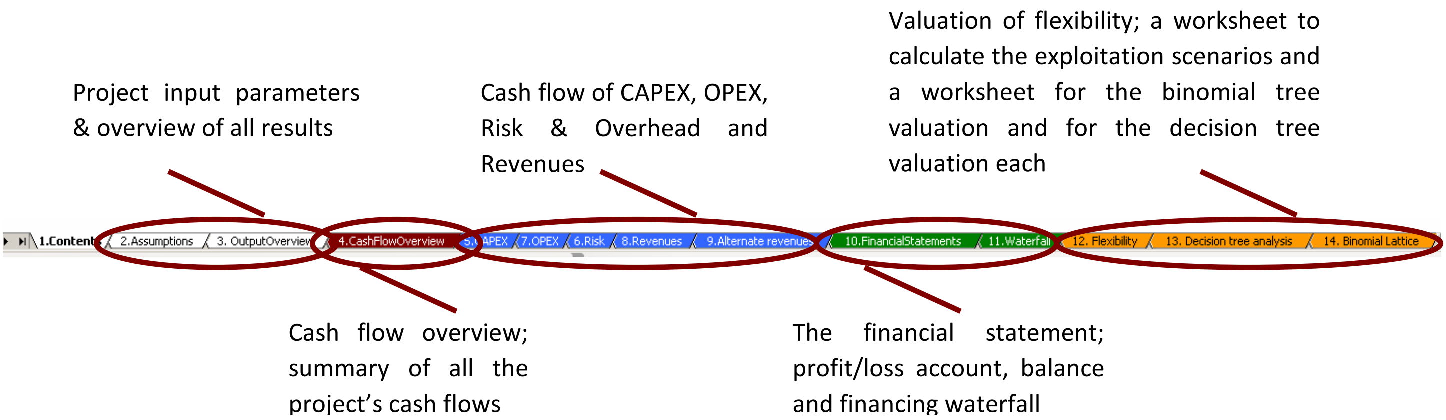


Figure 98 Overview of worksheets in the model

XII.1 Assumption worksheet and output overview (white)

The assumption worksheet contains all the project specfic assumption. All these parameters can be varied. The entire model is linked to the values in this worksheet. The yellow fields can be varied. The white fields are calculated using the parameters in the yellow field. Only the yellow field can be adjusted. The overview of the this worksheet is given in appendix V.

In the worksheet output overview all the results from the model are grouped together.

XII.2. Cash Flow Overview (dark red)

The cash flow worksheet is the central part of the model. In this worksheet all cash flows come together. In the blue line the results are calculated. The other components of the model are depicted below.

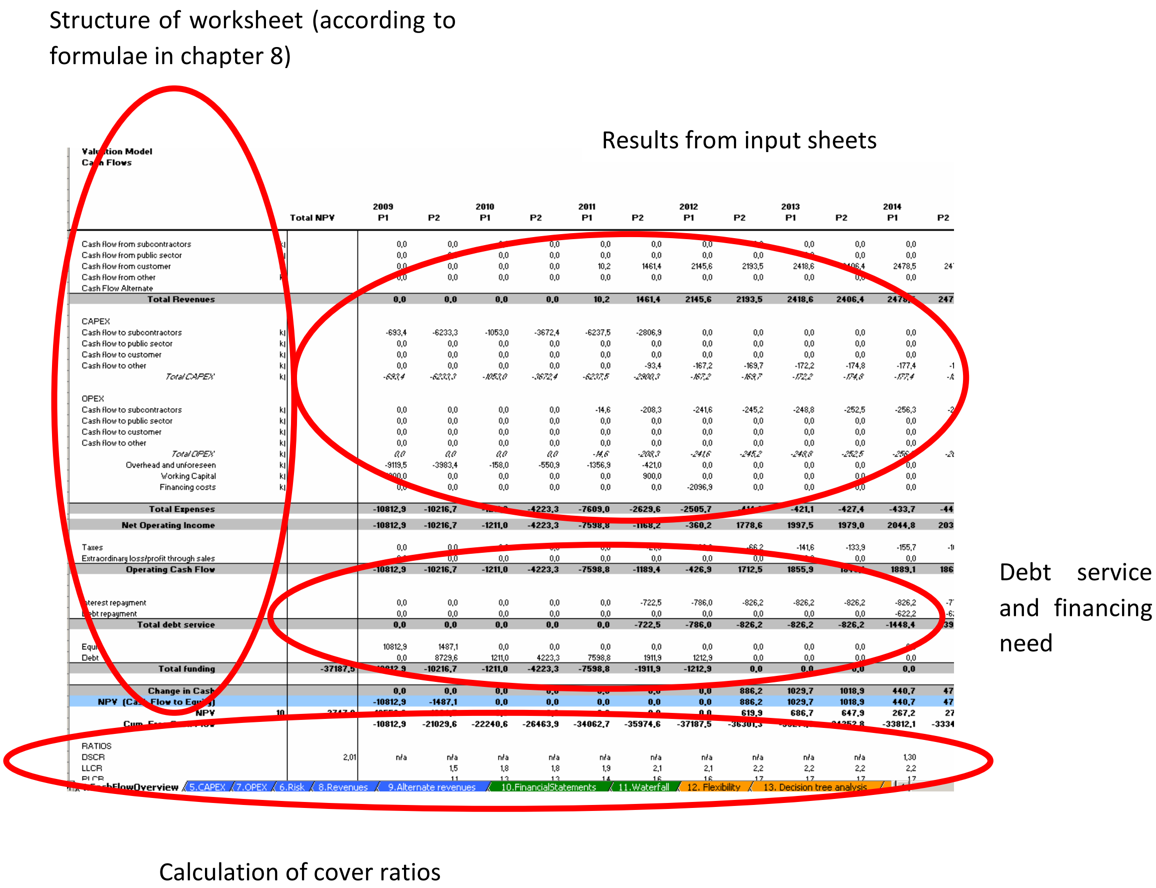


Figure 99 Structure of cash flow overview in the model

XII.2. Input sheets (CAPEX, OPEX, Risk and overhead and revenues) (light blue)

Figure 100 Structure of the input worksheets (CAPEX, OPEX, Risk & Overhead and Revenues)

XII.3 Financial Statements and Waterfall (green)

In the financial statements the income statement and the balance sheet are made. In the waterfall the financing structure is calculated. Both sheets are calculated automatically from the assumption sheet.

For the waterfall of financing components only equity and debt are modeled. It is assumed that equity is drawn first. For the financing structure the next parameters can be varied:

- Interest rates per period
- Duration of debt
- Grace period and repayment period of debt
- Drawdown schedule of debt
- Financing committed

XII.5. Flexibility (orange)

In the worksheet flexibility the cash flows are splitted into the phases of the project and variation to the base case are calculated using a macro. The other two work sheets contain the decision trees and the binomial trees as described in appendix VIII and IX. All these sheets are calculated automatically.

APPENDIX XIII – COMPANIES IN THE VALUE CHAIN

XIII.1.Companies in study

In the value chain analysis the activities in the value chain are researched by looking at the companies

active in each step of the value chain. In this appendix the companies are described, which are investigated. Two sorts of companies can be seen in the civil engineering market:

- Companies focusing on their expertise in one step of the value chain. These companies are discussed per step in the value chain in sections XII.2.2.-XII.2.6
- Construction companies active in multiple steps of the value chain. The activities of these companies are discussed in section XII.2.1. In this study the activities of the ten largest construction companies (based on revenues in 2007) are investigated plus van Hoogevest Construction Company.

XIII.2.1. Companies in multiple stages of the value chain

- **Royal BAM group**

  BAM Group NV is active in each step of the value chain. The BAM has activities in construction and property, infrastructure, public-private partnerships, installations and engineering consultancy. In addition, BAM has an interest in a dredging van Oord. In the annual reports BAM reports the income statement per segment since 2006. The respective segments and their allocatito a step in the value chain is as follows:

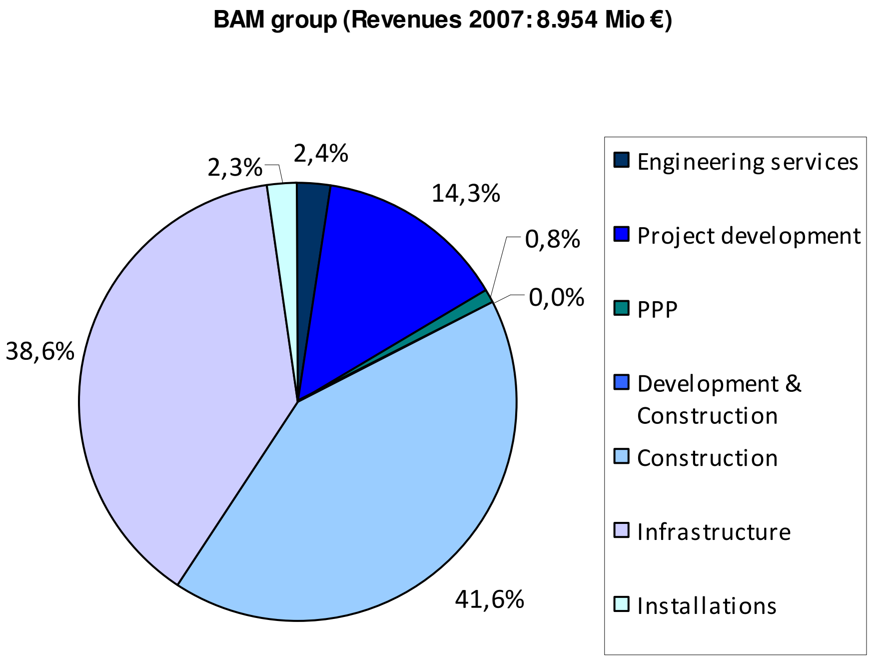


Figure 101 Distribution of revenues of BAM group over activities

- Tebodin Consultancy and Engineering (engineering services). Tebodin is an independent multidisciplinary consultancy office which is active globally. The consultancy takes mainly place in the industrial sector, real estate and oil and gas.
- BAM PPP (project development). BAM PPP represents the Royal BAM group in the sector Public Private partnerships. BAM PPP has 75 employees and is located in the Netherlands, Schotland, England, Ireland and Germany. The group focuses on PPP-

projects in all markets in which the BAM is present. In 2007 the Bam group is active in PPP projects worth € 2,5 Bio. This results in an equity share of € 125 Mio. In this division the revenues and results from operational PPP projects are listed. The profit has increased in 2007 because of a significant higher operational result, revenues and disinvestments

- Real Estate (project development) BAM Real Estate develops projects in utility and residents building projects and is mainly active in the Netherlands. Next to this BAM Real Estate is active in Belgium, United Kingdom and on smaller scale in Germany.
- Construction (construction) BAM construction focuses on the construction of utility and resident buildings and is mainly active in the Netherlands. Next to this BAM construction is active in Belgium, United Kingdom and Germany.
- Infrastructure (infrastructure). The division Infrastructure of the BAM constructs general civil engineering projects, such as road construction, energy and telecommunication. Subdivisions of BAM Infra are Bam Civil, Rail, Roads and Infra-technology. BAM Infra is mainly active in the Netherlands. Next to this BAM Infra is also active in Belgium, United Kingdom, Ireland and Germany.

All content in this appendix is retrieved from the financial report of the Royal Bam group NV 2007 and 2006 and from Thomson ONE banker database. The margins from the financial report are adjusted for two group costs and pension, which in the financial report are not allocated to the divisions initially. This adjustment of the group costs, groups interest and pensions is allocated linearly over the result of each division. For the year 2005 the financial numbers of the divisions BAM Construction and BAM Real Estate are not reported separately. Therefore they are not included in the respective tables.

- **Volker Wessels**

  Volker Wessels is the second largest construction company in the Netherlands based on revenues in 2007. The company has 17.000 employees with primary focus on the Dutch market. Secondary Volker Wessels is active in Europe and area development in the USA and Canada. The considered parts of Volker Wessels in this study are:

  - Construction and real estate Netherlands (project development & construction). Construction activities and real estate development activities are combined in the annual report of Volker Wessels.
  - Civil, Roads and Rail Europe (infrastructure). The main focus of Volker Wessels Infrastructure is in the Netherlands. Volker Wessels Infrastructure also has activities in Poland, Germany and the United Kingdom.

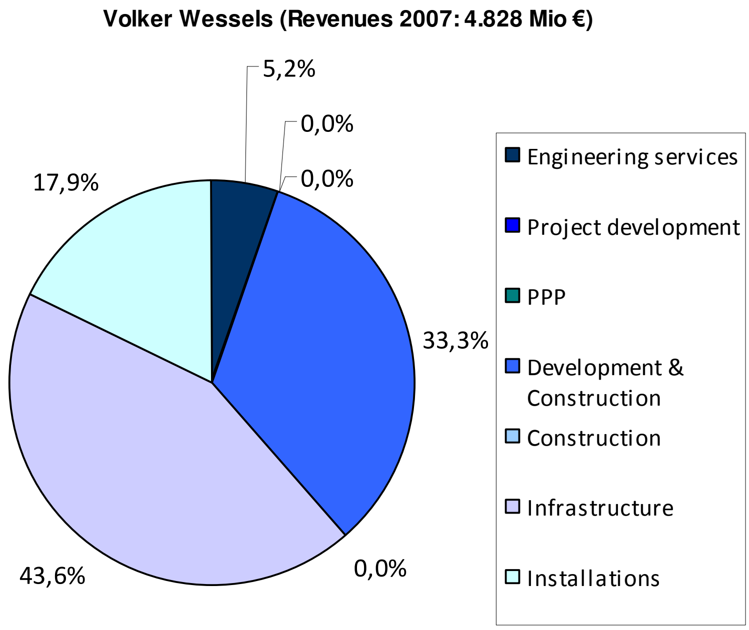


Figure 102 Distribution of revenues of Volker Wessels over activities

All content in this appendix is retrieved from the financial report of the Volker Wessels 2007 and 2006. No figures are available on the real estate or construction activities alone. The figures of outside Europe are not included in this study. The numbers listed for engineering services include the purchase department and are therefore left out of this study. Installations are outside the scope of this appendix.

- **Heijmans**

  Heijmans is a Dutch company in real estate, construction, Infrastructure and Installations listed on the Amsterdam stock exchange. Next to the main market the Netherlands, Heijmans is active in Belgium, the United Kingdom and Germany. Heijmans offers an intergrated solution over all the steps of the value chain from idea until maintenance and exploitation. In 2007 Heijmans started a new venture named Heijmans @Venture. The purpose of this venture is to participate in PPP projects.

  - Heijmans Real Estate (project development). The division Heijmans Real Estate targets on initiation, development and selling of especially houses and shops, offices, office areas, schools and health care institutions.
  - Heijmans Construction (construction). The construction division realizes constructions including maintenance and services in all market segments. The activities include new constructions on resident housing and utility buildings and on reconstruction and renovation. Special expertise is present in reconstruction of schools, health care institutions and airports.
  - Heijmans Infrastructure (infrastructure). Heijmans Infrastructure targets on design, advisory, execution and maintenance of ground, road, concrete and hydraulic structures. Next to this environment, recycling, technical and traffic infrastructure, sport facilities and industrial services.

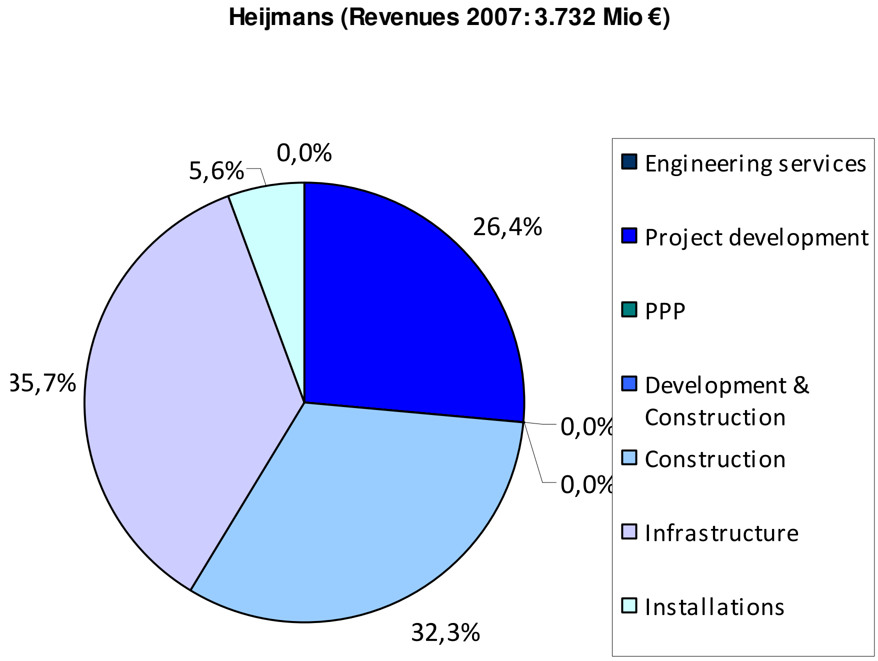


Figure 103 Distribution of revenues of Heijmans over activities

All content in this appendix is retrieved from the financial report of the Heijmans NV 2007 and 2006 and from Thomson ONE banker database.

- **TBI**
  A large share of the activities of TBI is in the field of installations. Next to this half of the activities is formed by project development and construction. These activities are investigated in the research.
  - TBI project development (project development)
  - TBI construction (construction)

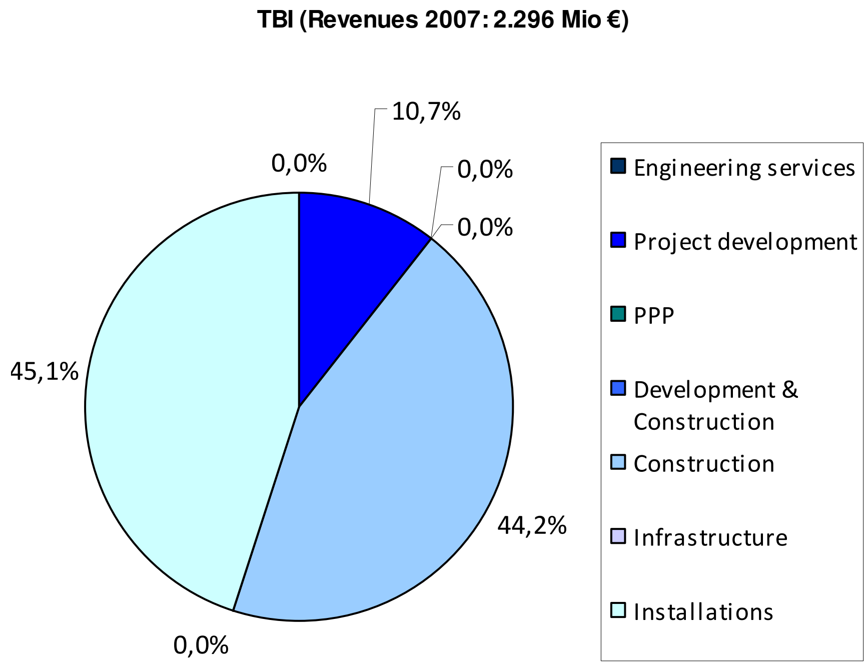


Figure 104 Distribution of revenues of TBI over activities

All content in this appendix is retrieved from the financial report of TBI 2007 and 2006

- **Ballast Nedam**

  Ballast Nedam is a Dutch construction firm with a wide range of products and services in the construction industry. Ballast Nedam develops infrastructure, constructs houses and other constructions and provides services and products which are related to these. The company targets mainly on the Dutch market. Next to this the company operates selectively internationally on area in which a competitive advantage is hold and in which it can operate profitable.

  Ballast Nedam is a large focus on infrastructure. Ballast Nedam has a strong PPP division with Ballast Nedam Concessions. However numbers of this part of Ballast Nedam are not presented in the annual report. This business unit is a joint venture of both divisions and develops projects and invests in them. The results of Ballast Nedam Concessions are consolidated in the figures of construction and infrastructure. From the projects described in the financial report can be estimated that Concessions has a turnover of around 120 Mio € .

  In the annual report the income state is specified for:
    - Project development and construction
    - Infrastructure

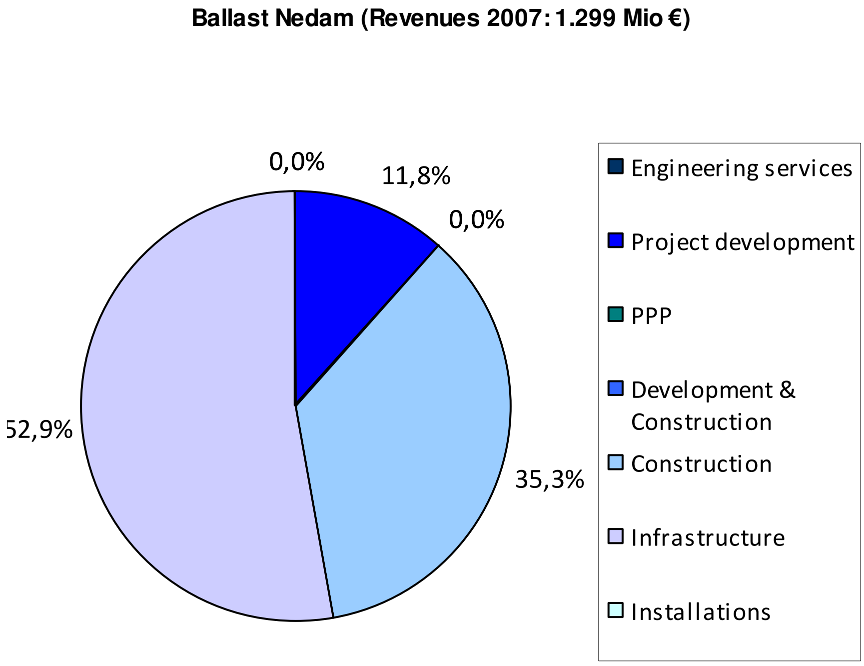


Figure 105 Distribution of revenues of Ballast Nedam over activities

All content in this appendix is retrieved from the financial report of the Ballast Nedam 2007 and 2006. No numbers are available for construction and development separately, although it is estimated that the share of development in revenues is similar as of the Bam Group (+/- 25%).

Other construction companies in this study are listed below. The share of the company's activities in each step of the value chain is presented in section XIII.3.4:

- **Dura Vermeer**

  Dura Vermeer has large share of activities in infrastructure. Advin engineering consultants is provide the engineering services of the company.

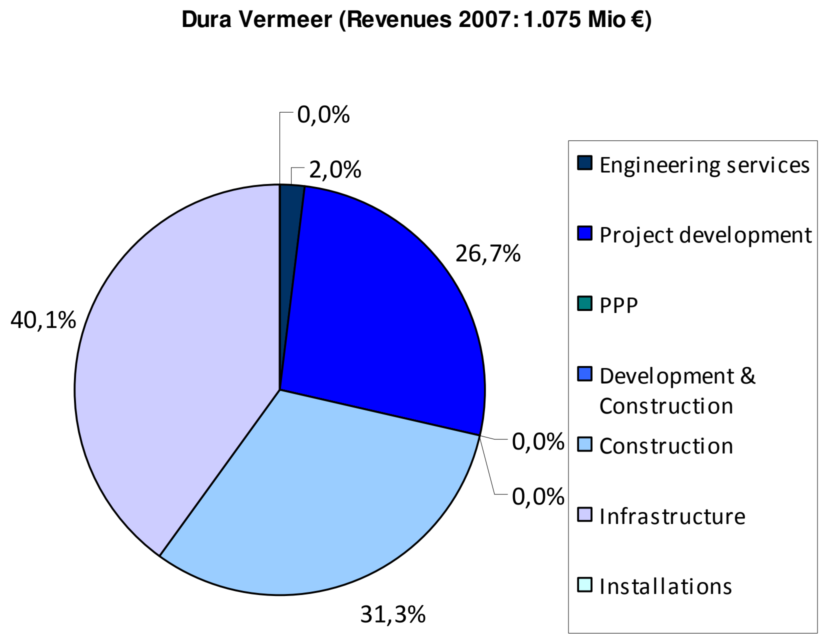


Figure 106 Distribution of revenues of Dura Vermeer over activities

- **Strukton**
  Strukton does not publish segmented income statements. Therefore the company is not included in the detailed study. However the division of the revenues over the different divisions is presented in the annual report.

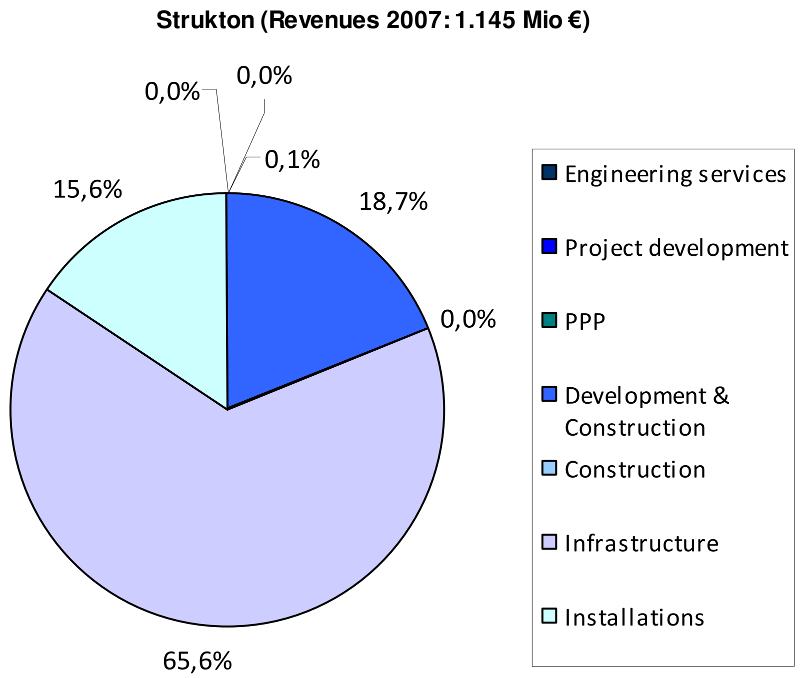


Figure 107 Distribution of revenues of Strukton over activities

The next three companies are relative smaller construction companies with project development activities next to construction.

- **Van Wijnen**

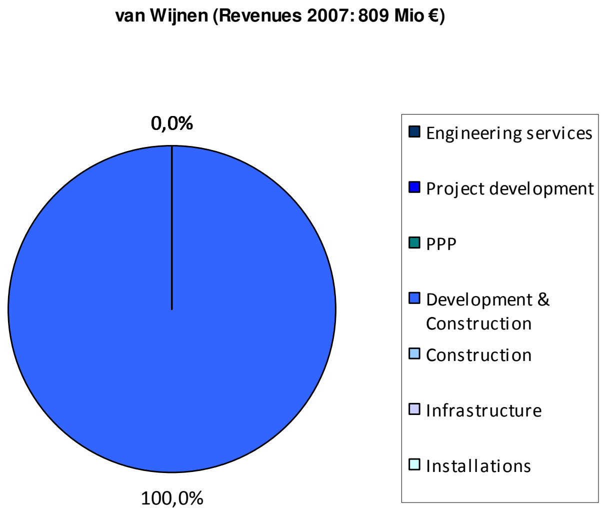


Figure 108 Distribution of revenues of van Wijnen over activities

- **Janssen de Jong**

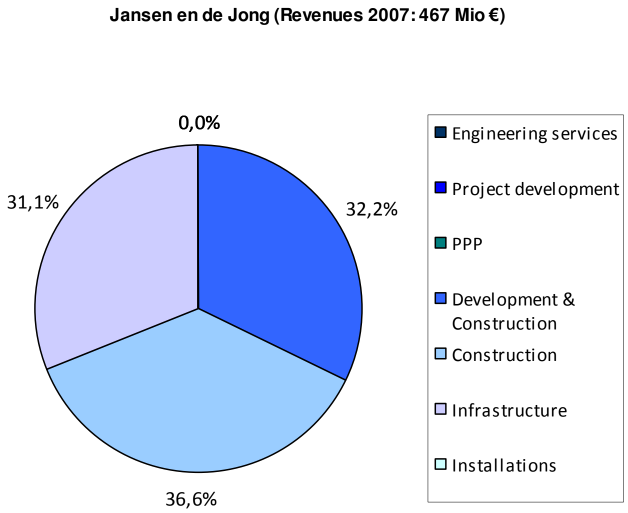


Figure 109 Distribution of revenues of Janssen de Jong over activities

- **Hurks**

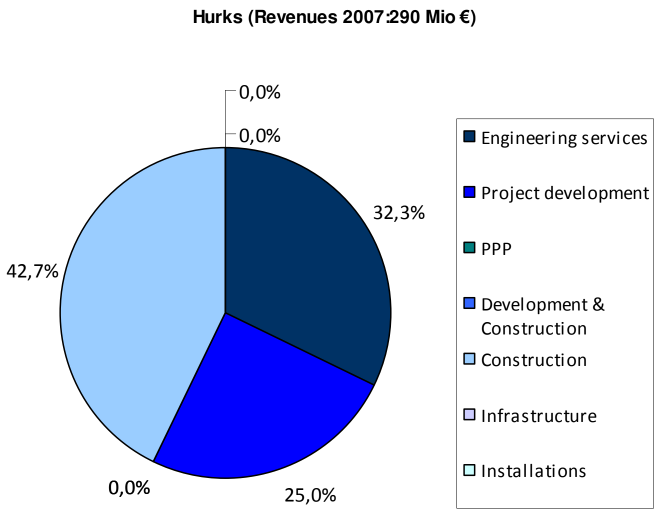


Figure 110 Distribution of revenues of Hurks over activities

- **van Hoogevest**

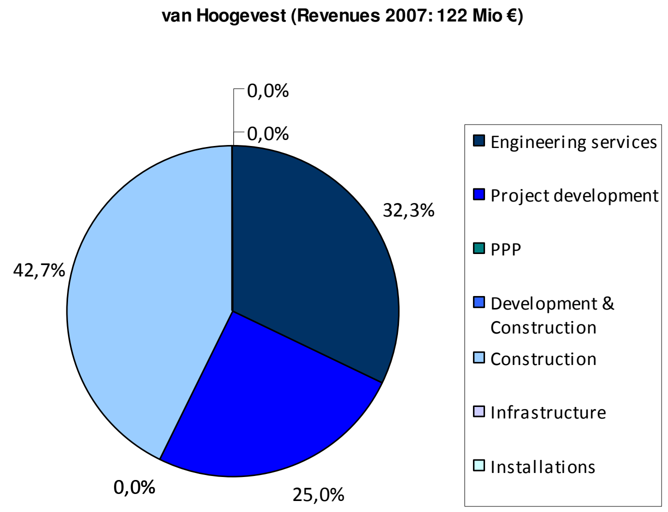


Figure 111 Distribution of revenues of van Hoogevest over activities

XIII.2.2. Engineering services

In this study 10 engineering consultants are investigated including the seven largest plus some smaller but leading engineering consultants. This group covers over 80% of the total market for engineering services in the Netherlands (based on the top-50 engineering consultants published by Iv-groep and Technisch weekblad).

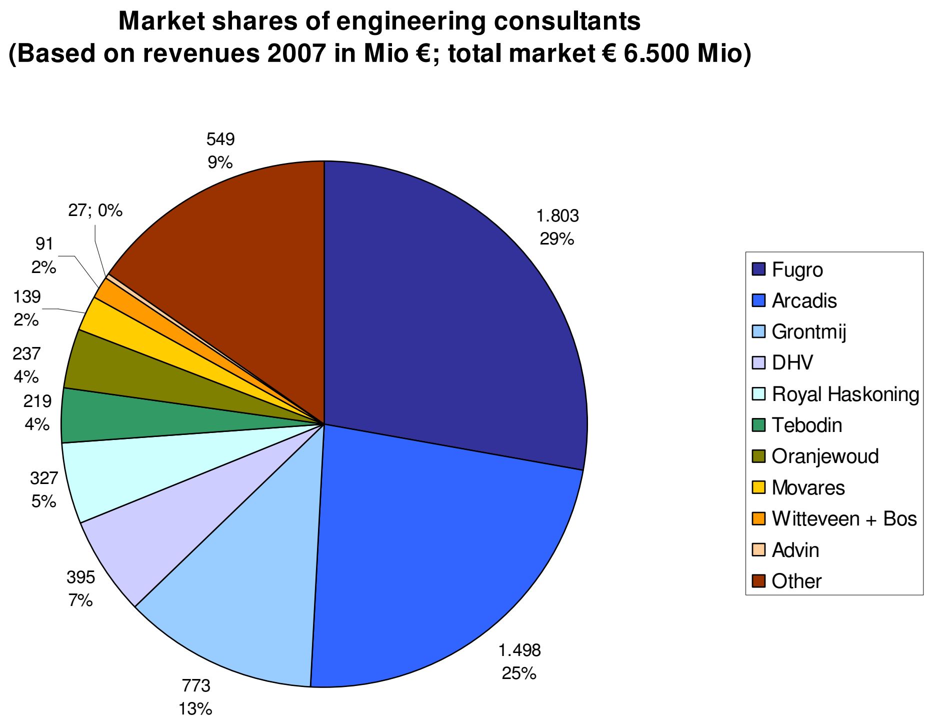


Figure 112 Market shares of Dutch engineering consultants

- **Fugro**

  Fugro is the largest engineering consultant in the Netherlands. Fugro specializes in highly specific engineering services in the field of geotechnics and geoengineering. Fugro is listed at the Amsterdam stock exchange. All content in this appendix is retrieved from the financial report of the Fugro NV 2007 and 2006 and from Thomson ONE banker database.

- **Arcadis**
  Arcadis is the largest general engineering consultant in the field of civil engineering in the Netherlands. Arcadis delivers engineering services in the whole range of civil engineering activities. Arcadis is listed at the Amsterdam stock exchange. All content in this appendix is retrieved from the financial report of the Arcadis 2007 and 2006 and from Thomson ONE banker database.

- **Grontmij**
  Grontmij is a Dutch consultancy and engineering firm with around 8.000 employees. The main market sectors on which Grontmij aims are Building and industry, Transportation and Environment, Water and Energy. Grontmij is listed at the Amsterdam stock exchange. All content in this appendix is retrieved from the financial report of the Grontmij NV 2007 and 2006 and from Thomson ONE banker database.

- **DHV**
  DHV is an internationally active engineering consultant active in the fields of Space & Mobility, construction and industry, Water and Aviation. All content in this appendix is retrieved from the financial report of the DHV 2007 and 2006

- **Royal Haskoning**
  Royal Haskoning is a globally active engineering consultant with expertise in the water and maritime sectors. All content in this appendix is retrieved from the financial report of the Royal Haskoning 2007 and 2006 and internal reports.

- **Oranjewoud**
  Oranjewoud is an engineering consultant which is listed on the Amsterdam stock exchange. After a financial reorganisation in 2005 and 2006 a large growth was visible in the revenues. Next to expertise in transport and mobility they give advice in the ICT sector. All content in this appendix is retrieved from the financial report of the Oranjewoud 2007 and 2006 and from Thomson ONE banker database.

- **Witteveen+Bos**
  Witteveen+ Bos is a Dutch engineering consultant active in niche market with highly specific advice. They only have a Dutch office and are considerably smaller than the other engineering consultants in this study. All content in this appendix is retrieved from the financial report of the Witteveen+Bos 2007 and 2006.

XIII.2.3. Project Developers

In the Dutch market a large variety of project developers is active. Project development can be categorized by

- the sort activities which generate the income of the company
- the sort real estate they invest in.

Real estate funds generally have three core activities: Project development, finance and investment management. In this study the focus is put on activities in project developing and financing which is done by most of the construction companies with a project development department. Real estate investment funds extend these activities with investing in real estate value papers. For some feeling with these numbers the Bouwfonds and ING real estate are included in the study as well.
Project development can be done on different sorts of real estate, roughly:

- residential real estate
- commercial real estate
- public real estate

- infrastructure.

Conventional real estate companies focus on the residential and commercial real estate. Large construction companies focus on the whole range of projects, including PPP projects which are generally in the public real estate an infrastructure. In this section therefore the whole range is included in the study.

In this study 7 project development companies are discussed with only developing activities. Next to the project development divisions of large construction firms, discussed above, the list is extended with three independent project developers, which are all not listed on the sotck exchange.

- **Bouwfonds**
  Bouwfonds is one of the largest real estate funds in Europe and is part of the Rabobank group since 2006. Bouwfonds is not listed at a stock exchange. They are both active in private and commercial real estate. The activities of Bouwfonds are grouped into Real estate development, finance and investment management. All content in this appendix is retrieved from the financial report of the Bouwfonds 2007 and 2006. Because a different form of income statement is used than other companies in this study the revenues are determined as all project revenues, interest revenues and provision revenues.

- **ING Real Estate**
  ING real estate is one of the largest real estate developers in the world and market leader in the Netherlands. INg real estate is not listed at a stock exchange. ING real estate is active in all fields of real estate. ING real estate focuses on real estate development, finance and investment management. All content in this appendix is retrieved from the financial report of ING Real Estate 2007 and 2006. Because a different form of income statement is used than other companies in this study the revenues are determined as all project revenues, interest revenues and provision revenues.

- **OVG Project Development**
  OVG Project Development is a Dutch real estate developer with an innovative approach. OVG is not listed at a stock exchange. The Dutch based organization actively seeks out opportunities for European expansion, both in the field of redevelopment (for example, restoring buildings or regenerating neighborhoods) and as a developer of uncultivated areas. Next to development of residential and commercial real estate, OVG founded this year a division for infrastructure development. The results are retrieved from the financial report of OVG of 2007 and 2006.

XIII.2.4. Operation

Operation of the construction includes all the activities that are needed on the interior of the construction to be able to exploit the construction. The constructive maintenance is included in the acitivity construction. Operation or facility management includes all operational maintenance. With the coming of these new contracts and the outsourcing of facility management by large companies, this market is developing.

- **Facilicom**
  Facilicom is a Dutch company which is specialized in the facility management. Facilicom takes part in DBFMO-tendering for the operation part, including security, construction maintenance, catering and cleaning. Facilicom was the first to win a facility management PPP tendering in the Netherlands. All content in this appendix is retrieved from the financial report of Facilicom 2007 and 2006

- **ISS Facility – the Netherlands**
  ISS is a Danish company active globally in the field of facility management. In the Netherland they are active with around 20.000 employees. Next to the standard facility services, ISS focuses on PPP projects for facility management. All content in this appendix is retrieved from the financial report of ISS international 2007 and 2006. The results are specific for the Netherlands, retrieved fro mthe appendices of the annual report. A recapitalization in 2007 lowered the earnings before tax in 2007 considerably.

APPENDIX XIV – FINANCIAL ANALYSIS

Engineering consultants and services

Arcadis	2007	2006	2005
Gross Revenues (Mio €)	1.510	1.233	1.001
Value Added (Mio €)	1.004	837	703
Operating Income (EBIT) (Mio €)	95	71	54
Earnings before Tax (Mio €)	86	67	54
# of employees	12.408	10.728	10.043
EBT-margin (%)	5,7%	5,4%	5,4%
EBT-margin (on value added) (%)	8,5%	7,9%	7,7%
Added value per employee (k €)	81	78	70

Royal Haskoning	2007	2006	2005
Gross Revenues (Mio €)	326	274	220
Added Value (Mio €)	245	211	171
Operating Income (EBIT) (Mio €)	16	14	11
Earnings before Tax (Mio €)	15	14	11
# of employees	3.057	2.985	2.454
EBT-margin (%)	4,7%	5,2%	5,1%
EBT-margin (on value added) (%)	6,2%	6,8%	6,5%
Added value per employee (k €)	80	71	70

Grontmij	2007	2006	2005
Gross Revenues (Mio €)	773	543	442
Added Value (Mio €)	598	385	294
Operating Income (EBIT) (Mio €)	48	30	20
Earnings before Tax (Mio €)	41	24	16
# of employees	6.656	6.337	3.514
EBT-margin (%)	5,3%	4,5%	3,6%
EBT-margin (on value added) (%)	6,8%	6,3%	5,4%
Added value per employee (k €)	90	61	84

DHV	2007	2006	2005
Net Revenues (Mio €)	395	352	301
Added Value (Mio €)	275	269	229
Operating Income (EBIT) (Mio €)	12	12	6
Earnings before Tax (Mio €)	10	10	4
# of employees	4.730	4.353	4.054
EBT-margin (%)	2,5%	2,8%	1,3%
EBT-margin (on value added) (%)	3,6%	3,7%	1,7%
Added value per employee (k €)	58	62	56

Oranjewoud*	2007	2006	2005
Revenues (Mio €)	236	182	178

Added value (Mio €)	164	115	117
Operating Income (EBIT) (Mio €)	22	9	7
Earnings before Tax (Mio €)	22	9	7
# of employees	1.444	1.501	1.556
EBT-margin (%)	9,4%	5,0%	4,0%
EBT-margin (on value added) (%)	13,6%	7,9%	6,0%
Added value per employee (k €)	114	77	75

Witteveen+Bos	2007	2006	2005
Gross Revenues (Mio €)	91	82	81
Added Value (Mio €)	67	62	59
Operating Income (EBIT) (Mio €)	15	13	12
Earnings before Tax (Mio €)	14	12	12
# of employees	708	661	661
EBT-margin (%)	15,7%	15,1%	14,6%
EBT-margin (on value added) (%)	21,2%	20,2%	20,0%
Added value per employee (k €)	95	93	89

BAM group - Tebodin	2007	2006	2005
Gross Revenues (Mio €)	219	204	166
Added Value (Mio €)	173	159	127
Operating Income (EBIT) (Mio €)	28	25	15
Earnings before Tax (Mio €)	28	25	15
# of employees	2.704	2.511	2.065
EBT-margin (%)	13,0%	12,3%	9,0%
EBT-margin (on value added) (%)	16,4%	15,8%	11,7%
Added value per employee (k €)	64	63	61

Dura Vermeer - Advin	2007	2006	2005
Gross Revenues (Mio €)	21	22	18
Added Value (Mio €)(estimation)	16	17	14
Operating Income (EBIT) (Mio €)	2	2	1
Earnings before Tax (Mio €)	2	2	1
# of employees	207	202	220
EBT-margin (%)	7,6%	8,2%	7,2%
EBT-margin (on value added) (%)	10,2%	10,9%	9,6%
Added value per employee (k €)	76	82	61

Fugro	2007	2006	2005
Gross Revenues (Mio €)	1.803	1.434	1.161
Added Value (Mio €)(estimation)	1.198	931	755
Operating Income (EBIT) (Mio €)	325	212	144
Earnings before Tax (Mio €)	294	185	128
# of employees	10.824	9.261	8.121
EBT-margin (%)	16,3%	12,9%	11,0%
EBT-margin (on value added) (%)	24,5%	19,9%	17,0%
Added value per employee (k €)	111	101	93

Movares	2007	2006	2005
Gross Revenues (Mio €)	139	137	141
Added Value (Mio €)(estimation)			
Operating Income (EBIT) (Mio €)	9	5	7
Earnings before Tax (Mio €)	8	3	6
# of employees	1.207	1.205	1.203
EBT-margin (%)	5,9%	2,3%	4,4%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Added value per employee (k €)	0	0	0

Real estate development

OVG	2007	2006	2005
Gross Revenues (Mio €)	327	183	111
Added Value (Mio €)	36	33	19
Operating Income (EBIT) (Mio €)	24	26	15
Earnings before Tax (Mio €)	30	27	15
# of employees (staff)	56	40	27
EBT-margin (%)	9,1%	14,6%	13,3%
EBT-margin (on value added) (%)	81,9%	81,0%	80,0%
Added value per staff employee (k €)	650	828	685

BAM PPP	2007	2006	2005
Gross Revenues (Mio €)	73	70	40
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	47	28	10
Earnings before Tax (Mio €)	29	2	-6
# of employees	75	65	40
EBT-margin (%)	39,8%	3,1%	-14,2%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Added value per employee (k €)	0	0	0

BAM Real Estate	2007	2006	2005 (est.)
Gross Revenues (Mio €)	1.304	1.376	n/a
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	103	119	n/a
Earnings before Tax (Mio €)	96	94	n/a
# of employees			
EBT-margin (%)	7,3%	6,8%	n/a
EBT-margin (on value added) (%)	n/a	n/a	n/a
Added value per employee (k €)	n/a	n/a	n/a

Heijmans Real estate	2007	2006	2005
Gross Revenues (Mio €)	1.084	911	941
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	85	85	71
Earnings before Tax (Mio €)	77	74	56

# of employees			
EBT-margin (%)	7,1%	8,1%	5,9%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Added value per employee (k €)	n/a	n/a	n/a

Rabo Real estate / Rabo Bouwfonds	2007	2006	2005
Total income from projects (Mio €)	3.511	2.513	2.141
Added Value (Mio €)	400	353	265
Operating Income (EBIT) (Mio €)	137	179	99
Earnings before Tax (Mio €)	315	136	74
# of employees	1.918	1.783	2.380
EBT-margin (%)	9,0%	5,4%	3,4%
EBT-margin (on value added) (%)	78,9%	38,6%	27,8%
Added value per employee (k €)	208	198	111

ING Real Estate	2007	2006	2005
Total income from projects (Mio €)	2.984	2.792	1.513
Added Value (Mio €)	881	735	412
Operating Income (EBIT) (Mio €)	321	277	64
Earnings before Tax (Mio €)	723	637	383
# of employees	2.549	2.100	1.778
EBT-margin (%)	24,2%	22,8%	25,3%
EBT-margin (on value added) (%)	82,1%	86,6%	92,8%
Added value per employee (k €)	345	350	232

TBI Real Estate	2007	2006	2005
Total income from projects (Mio €)	245	91	104
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	18	6	8
Earnings before Tax (Mio €)	18	6	8
# of employees	204	88	
EBT-margin (%)	7,3%	6,2%	7,3%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Added value per employee (k €)	0	0	n/a

Real estate development and construction

Ballast Nedam	2007	2006	2005
Gross Revenues (Mio €)	601	622	658
Estimated Value Added (Mio €) (ratio BN N.V.)	164	160	190
Operating Income (EBIT) (Mio €)	33	36	35
Earnings before Tax (Mio €)(ratio BN NV)	30	33	29
# of employees	1.634	1.594	1.622
EBT-margin (%)	5,0%	5,3%	4,4%
EBT-margin (on value added) (%)	18,3%	20,6%	15,3%
Value Added per employee (k €)	100	101	117

Volker Wessels	2007	2006	2005
Gross Revenues (Mio €)	1.701	1.392	1.206
Added Value (Mio €) (ratio VW NV)	432	359	326
Operating Income (EBIT) (Mio €)	103	93	82
Earnings before Tax (Mio €)(ratio VW N.V.)	100	93	84
# of employees	3.200	3.100	3.000
EBT-margin (%)	5,9%	6,7%	7,0%
EBT-margin (on value added) (%)	23,1%	25,8%	25,8%
Value Added per employee (k €)	135	116	109

Dura Vermeer	2007	2006	2005
Gross Revenues (Mio €)	623	606	620
Added Value (Mio €) (ratio DV NV)	124	134	130
Operating Income (EBIT) (Mio €)	27	28	28
Earnings before Tax (Mio €)(ratio DV N.V.)	31	32	31
# of employees	1.344	1.331	1.334
EBT-margin (%)	5,0%	5,2%	5,0%
EBT-margin (on value added) (%)	24,9%	23,7%	23,8%
Value Added per employee (k €)	92	100	98

van Wijnen	2007	2006	2005
Gross Revenues (Mio €)	809	690	0
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	27	21	0
Earnings before Tax (Mio €)(ratio DV N.V.)	24	20	0
# of employees	1.694	1.503	0
EBT-margin (%)	3,0%	2,8%	0
EBT-margin (on value added) (%)	n/a	n/a	n/a
Value Added per employee (k €)	0	0	n/a

Construction

BAM Construction	2007	2006	2005
Gross Revenues (Mio €)	3.791	3.393	n/a
Added Value (Mio €)			n/a
Operating Income (EBIT) (Mio €)	60	-53	n/a
Earnings before Tax (Mio €)	88	-30	n/a
# of employees (+/-)	9.000		
EBT-margin (%)	2,3%	-0,9%	n/a
EBT-margin (on value added) (%)	n/a	n/a	n/a
Value Added per employee (k €)	n/a	n/a	n/a

Heijmans Construction	2007	2006	2005
Gross Revenues (Mio €)	1.323	1.210	1.214
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	-41	13	36
Earnings before Tax (Mio €)	-36	20	39
# of employees			
EBT-margin (%)	-2,7%	1,6%	3,2%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Value Added per employee (k €)	n/a	n/a	n/a

TBI Construction	2007	2006	2005
Gross Revenues (Mio €)	1.015	938	869
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	13	17	19
Earnings before Tax (Mio €)	14	18	20
# of employees	2.253	2.544	2.625
EBT-margin (%)	1,4%	1,9%	2,3%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Value Added per employee (k €)	n/a	n/a	n/a

Van Hoogevest Construction	2007	2006	2005
Gross Revenues (Mio €)(estimated from net revenues)	163	167	163
Added Value (Mio €)	31	36	31
Operating Income (EBIT) (Mio €)	-8	1	5
Earnings before Tax (Mio €)	-7	1	4
# of employees	419	401	363
EBT-margin (%)	-4,3%	0,3%	2,1%
EBT-margin (on value added) (%)	-22,9%	1,4%	11,5%
Value Added per employee (k €)	73	90	84

Infrastructure

BAM Infrastructure	2007	2006	2005
Gross Revenues (Mio €)	3.512	3.346	3.510
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	94	103	143
Earnings before Tax (Mio €)	111	119	157
# of employees (+/-)	12.500		
EBT-margin (%)	3,2%	3,6%	4,5%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Value Added per employee (k €)	n/a	n/a	n/a

Ballast Nedam Infrastructure	2007	2006	2005
Gross Revenues (Mio €)	675	676	541
Added Value (Mio €)(ratio BN Nv)	184	174	156
Operating Income (EBIT) (Mio €)	18	16	14
Earnings before Tax (Mio €)	17	15	10
# of employees	2.098	1.977	1.934
EBT-margin (%)	2,5%	2,2%	1,8%
EBT-margin (on value added) (%)	9,2%	8,6%	6,4%
Value Added per employee (k €)	88	88	81

Heijmans Infrastructure	2007	2006	2005
Gross Revenues (Mio €)	1.463	1.068	945
Added Value (Mio €)			
Operating Income (EBIT) (Mio €)	35	34	36
Earnings before Tax (Mio €)	26	34	34
# of employees			
EBT-margin (%)	1,8%	3,1%	3,6%
EBT-margin (on value added) (%)	n/a	n/a	n/a
Value Added per employee (k €)	n/a	n/a	n/a

Volker Wessels Infrastructure	2007	2006	2005
Gross Revenues (Mio €)	2.002	2.005	1.583
Added Value (Mio €) (ratio VW NV)	508	518	428
Operating Income (EBIT) (Mio €)	30	40	49
Earnings before Tax (Mio €)	30	40	50
# of employees	7.200	7.100	6.900
EBT-margin (%)	1,5%	2,0%	3,2%
EBT-margin (on value added) (%)	5,9%	7,7%	11,8%
Value Added per employee (k €)	71	73	62

Dura Vermeer Infrastructure	2007	2006	2005
Gross Revenues (Mio €)	431	413	407
Added Value (Mio €) (ratio DV NV)	86	91	86

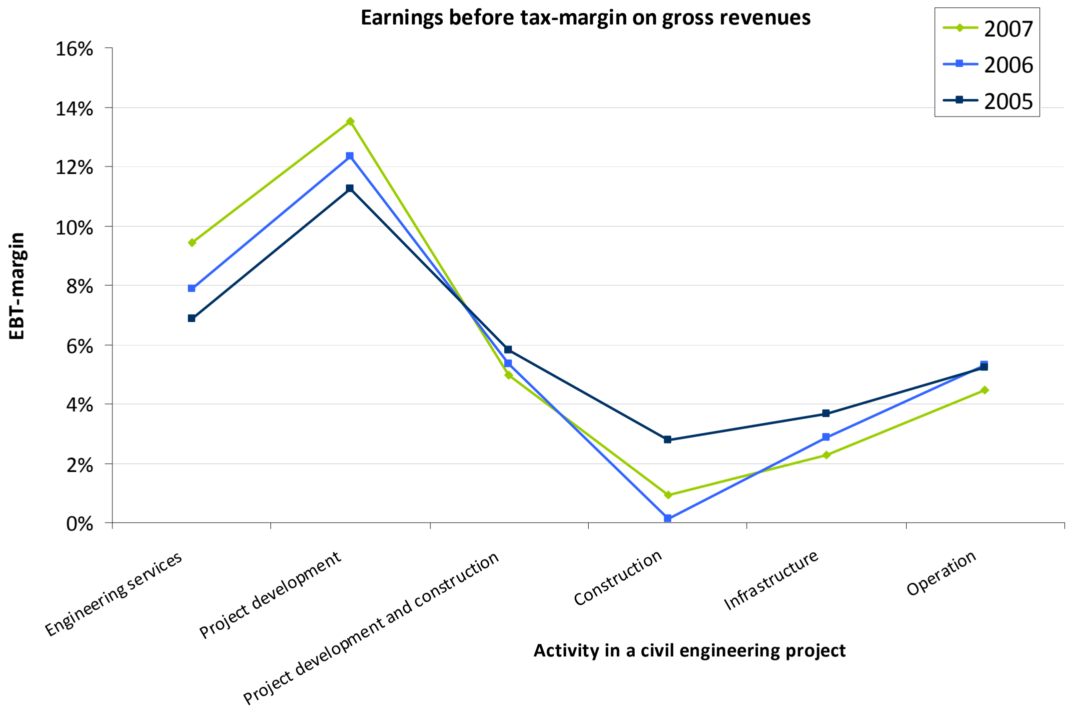
Operating Income (EBIT) (Mio €)	-1	7	5
Earnings before Tax (Mio €)	1	9	6
# of employees	1.509	1.592	1.644
EBT-margin (%)	0,2%	2,2%	1,5%
EBT-margin (on value added) (%)	1,2%	9,9%	7,0%
Value Added per employee (k €)	57	57	52

Operation

Facilicom	2007	2006	2005
Gross Revenues (Mio €)	809	832	618
Added Value (Mio €)	682	659	481
Operating Income (EBIT) (Mio €)	49	45	34
Earnings before Tax (Mio €)	50	45	35
# of employees	28.208	27.210	21.485
EBT-margin (%)	6,2%	5,4%	5,6%
EBT-margin (on value added) (%)	7,3%	6,8%	7,2%
Value Added per employee (k €)	24	24	22

ISS Facility Management - Netherlands	2007	2006	2005
Gross Revenues (Mio €)	490	467	474
Added Value (Mio €)	446	423	400
Operating Income (EBIT) (Mio €)	30	33	27
Earnings before Tax* (Mio €)	8	24	22
# of employees	20.941	21.534	21.024
EBT-margin (%)	1,6%	5,1%	4,6%
EBT-margin (on value added) (%)	1,8%	5,7%	5,5%
Value Added per employee (k €)	21	20	19

APPENDIX XV - EBT-MARGIN OVER VALUE CHAIN



Engineering services

Company	2007		2006		2005	
Fugro	16,3%	1.803	12,9%	1.434	11,0%	1.161
Arcadis	5,7%	1.510	5,4%	1.233	5,4%	1.001
Grontmij	5,3%	773	4,5%	543	3,6%	442
DHV	2,5%	395	2,8%	352	1,3%	301
Royal Haskoning	4,7%	326	5,2%	274	5,1%	220
Oranjewoud	9,4%	236	5,0%	182	4,0%	178
BAM group - Tebodin	13,0%	219	12,3%	204	9,0%	166
Movares	5,9%	139	2,3%	137	4,4%	141
Witteveen + Bos	15,7%	91	15,1%	82	14,6%	81
Dura Vermeer - Advin	7,6%	21	8,2%	22	7,2%	18
Weighted average (%) Total (Mio €)	9,4%	5.512	7,9%	4.463	6,9%	3.707

Project development

Company	2007		2006		2005	
Rabo Real estate	9,0%	3.511	5,4%	2.513	3,4%	2.141
ING Real Estate	24,2%	2.984	22,8%	2.792	25,3%	1.513
BAM Real Estate	7,3%	1.304	6,4%	1.376	n/a	n/a
Heijmans Real Estate	7,1%	1.084	9,3%	911	7,5%	941

OVG	9,1%	327	14,6%	183	13,3%	111
TBI Real Estate	7,3%	245	6,2%	91	7,3%	104
BAM PPP	39,8%	73	3,0%	70	-11,8%	40
Weighted average (%) Total (Mio €)	13,5%	9.528	12,3%	7.936	11,2%	4.850

Real estate development and construction

Company	2007		2006		2005	
Ballast Nedam real estate and construction	5,0%	601	5,3%	622	4,4%	658
Volker Wessel real estate and construction	5,9%	1.701	6,7%	1.392	7,0%	1.206
Dura Vermeer real estate and construction	5,0%	623	5,2%	606	5,0%	620
van Wijnen real estate and constrution	3,0%	809	2,8%	690	n/a	n/a
Weighted average (%) Total (Mio €)	4,9%	3.734	5,3%	3.310	5,8%	2.484

Construction

Company	2007		2006		2005	
BAM Construction	2,3%	3.791	-0,9%	3.393	n/a	n/a
Heijmans Construction	-2,7%	1.323	1,6%	1.210	3,2%	1.214
TBI Construction	1,4%	1.015	1,9%	938	2,3%	869
van Hoogevest construction	-4,3%	163	0,3%	167	2,1%	163
Weighted average (%) Total (Mio €)	0,9%	6.292	0,1%	5.708	2,8%	2.246

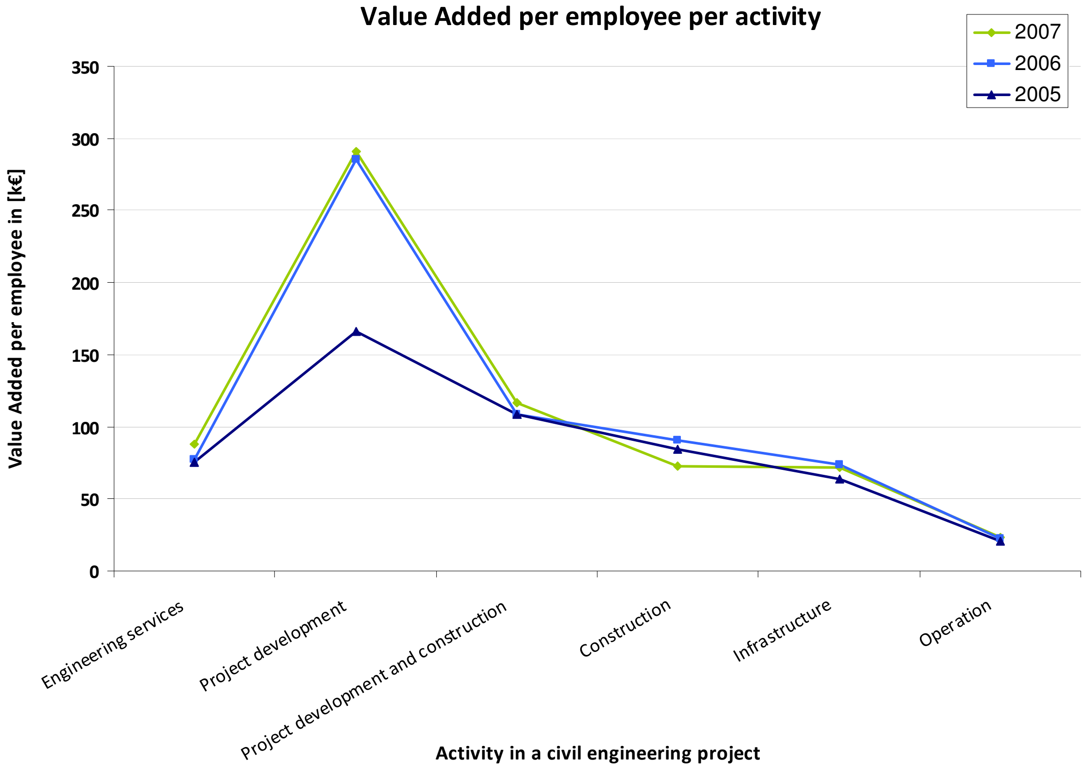
Infrastructure

Company	2007		2006		2005	
BAM Infrastructure	3,2%	3.512	3,6%	3.346	4,5%	3.510
Volker Wessel Infrastructure	1,5%	2.002	2,0%	2.005	3,2%	1.583
Heijmans Infrastructure	1,8%	1.463	3,1%	1.068	3,6%	945
BN Infrastructure	2,5%	675	2,2%	676	1,8%	541
Dura Vermeer Infrastructure	0,2%	431	2,2%	413	1,5%	407
Weighted average (%) Total (Mio €)	2,3%	8.083	2,9%	7.508	3,7%	6.986

Exploitation

Company	2007		2006		2005	
Facilicom	6,2%	809	5,4%	83180,0%	5,6%	618
ISS Facility Management Netherlands	-1,6%	490	5,1%	467	4,6%	474
Weighted average (%) Total (Mio €)	4,4%	1.300	5,3%	1.299	5,2%	1.092

APPENDIX XVI – ADDED VALUE PER EMPLOYEE OVER VALUE CHAIN



Engineering services

Company	2007		2006		2005	
Oranjewoud	114	1.444	77	1.501	75	1.556
Fugro	111	10.824	101	9.261	93	8.121
Witteveen + Bos	95	708	93	661	89	661
Grontmij	90	6.656	61	6.337	84	3.514
Arcadis	81	12.408	78	10.728	70	10.043
Royal Haskoning	80	3.057	71	2.985	70	2.454
Dura Vermeer - Advin	76	207	82	202	61	220
BAM group - Tebodin	64	2.704	63	2.511	61	2.065
DHV	58	4.730	62	4.353	56	4.054
Weighted average (%)						
Total (Mio €)	88	42.738	77	38.539	75	32.688

Project development

Company	2007		2006		2005	
OVG	650	56	828	40	685	27
ING Real Estate	345	2.549	350	2.100	232	1.778

Rabo Real estate	208	1.918	198	1.783	111	2.380
Weighted average (%)						
Total (Mio €)	291	4.523	286	3.923	166	4.185

Real estate development and construction

Company	2007		2006		2005	
Ballast Nedam real estate and construction	100	1.634	101	1.594	117	1.622
Volker Wessel real estate and construction	135	3.200	116	3.100	109	3.000
Dura Vermeer real estate and construction	92	1.344	100	1.331	98	1.334
Weighted average (%)						
Total (Mio €)	117	6.178	108	6.025	108	5.956

Construction

Company	2007		2006		2005	
Van Hoogevest Construction	73	419	90	401	84	363
Weighted average (%)						
Total (Mio €)	73	419	90	401	84	363

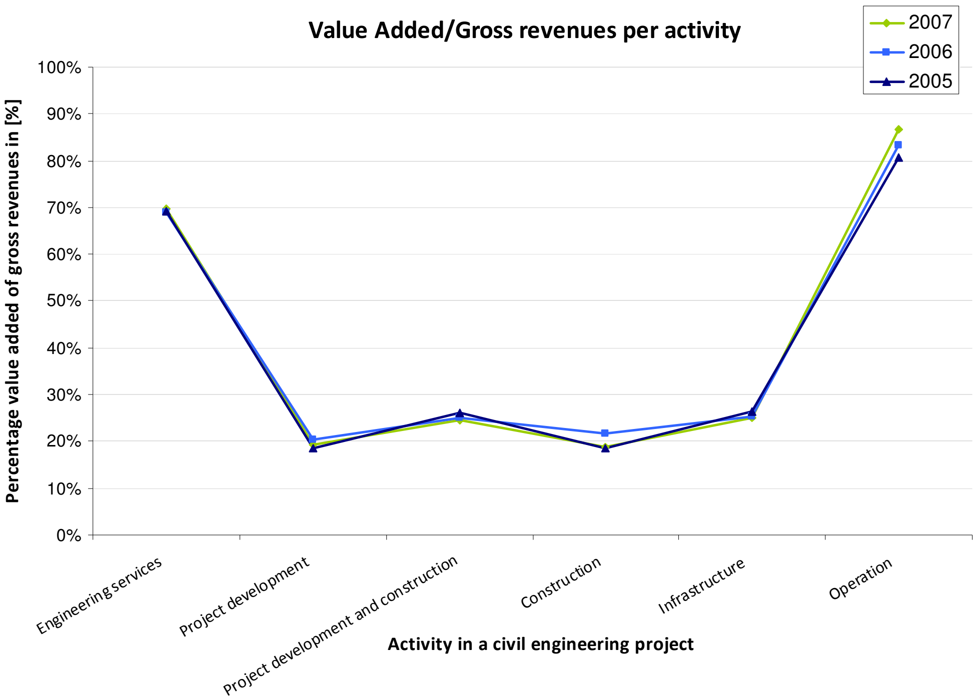
Infrastructure

Company	2007		2006		2005	
BN Infrastructure	88	2.098	88	1.977	81	1.934
Volker Wessel Infrastructure	71	7.200	73	7.100	62	6.900
Dura Vermeer Infrastructure	57	1.509	57	1.592	52	1.644
Weighted average (%)						
Total (Mio €)	72	10.807	73	10.669	64	10.478

Exploitation

Company	2007		2006		2005	
Facilicom	24	28.208	24	27.210	22	21.485
ISS facility management - Netherlands	21	20941	20	21534	19	21024
Weighted average (%)						
Total (Mio €)	23	49.149	22	48.744	21	42.509

APPENDIX XVII – ADDED VALUE OVER VALUE CHAIN



	Engineering services	Project Development	Construction	Infrastructure
Market size (Mio €)	6.500	30.000	30.000	25.000
Added value/Revenues (%)	70%	19%	20%	26%
Total Added value	4.550	5.700	6.000	6.500

Engineering services EBIT-margins on gross revenue and gross revenue

Company	2007		2006		2005	
BAM group - Tebodin	79,0%	219	77,7%	204	76,5%	166
Grontmij	77,4%	773	70,8%	543	66,5%	442
Royal Haskoning	75,3%	326	77,1%	274	78,0%	220
Dura Vermeer - Advin	75,0%	21	75,0%	22	75,0%	18
Witteveen + Bos	73,9%	91	74,8%	82	72,9%	81
DHV	69,6%	395	76,6%	352	76,2%	301
Oranjewoud	69,5%	236	63,5%	182	65,6%	178
Arcadis	66,5%	1.510	67,9%	1.233	70,2%	1.001
Fugro	66,5%	1.803	64,9%	1.434	65,0%	1.161
Weighted average (%)						
Total (Mio €)	69,6%	5.374	69,0%	4.326	69,2%	3.566

Project development

Company	2007	2006	2005

OVG	11,1%	327	18,0%	183	16,6%	111
ING Real Estate	29,5%	2.984	26,3%	2.792	27,2%	1.513
Rabo Real estate	11,4%	3.511	14,0%	2.513	12,4%	2.141
Weighted average (%) Total (Mio €)	19,3%	6.822	20,4%	5.489	18,5%	3.765

Real estate development and construction

Company	2007		2006		2005	
Ballast Nedam real estate and construction	27,3%	601	25,8%	622	28,9%	658
Volker Wessel real estate and construction	25,4%	1.701	25,8%	1.392	27,0%	1.206
Dura Vermeer real estate and construction	20,0%	623	22,1%	606	21,0%	620
Weighted average (%) Total (Mio €)	24,6%	2.925	24,9%	2.620	26,0%	2.484

Construction

Company	2007		2006		2005	
Van Hoogevest construction	18,8%	163	21,7%	167	18,7%	163
Weighted average (%) Total (Mio €)	18,8%	163	21,7%	167	18,7%	163

Infrastructure

Company	2007		2006		2005	
BN Infrastructure	27,3%	675	25,7%	676	28,9%	541
Volker Wessel Infrastructure	25,4%	2.002	25,8%	2.005	27,0%	1.583
Dura Vermeer Infrastructure	19,9%	431	22,0%	413	21,0%	407
Weighted average (%) Total (Mio €)	25,0%	3.108	25,3%	3.094	26,5%	2.531

Exploitation

Company	2007		2006		2005	
Facilicom	84,2%	809	79,2%	832	77,8%	618
ISS facility management - Netherlands	91,0%	490	90,6%	467	84,5%	474
Weighted average (%) Total (Mio €)	86,8%	1.300	83,3%	1.299	80,7%	1.092

APPENDIX XVIII – PROFITABILITY VERSUS MARKET RISK

Engineering services stocks		
Company	Beta* 36 months	Revenues 2007
Fugro	1,15	1.803
Grontmij	0,91	773
Arcadis	0,77	1.510
Oranjewoud	0,61	236
Average	0,86	
Weigthed average	0,94	

* source: Thomson ONE banker; datastream

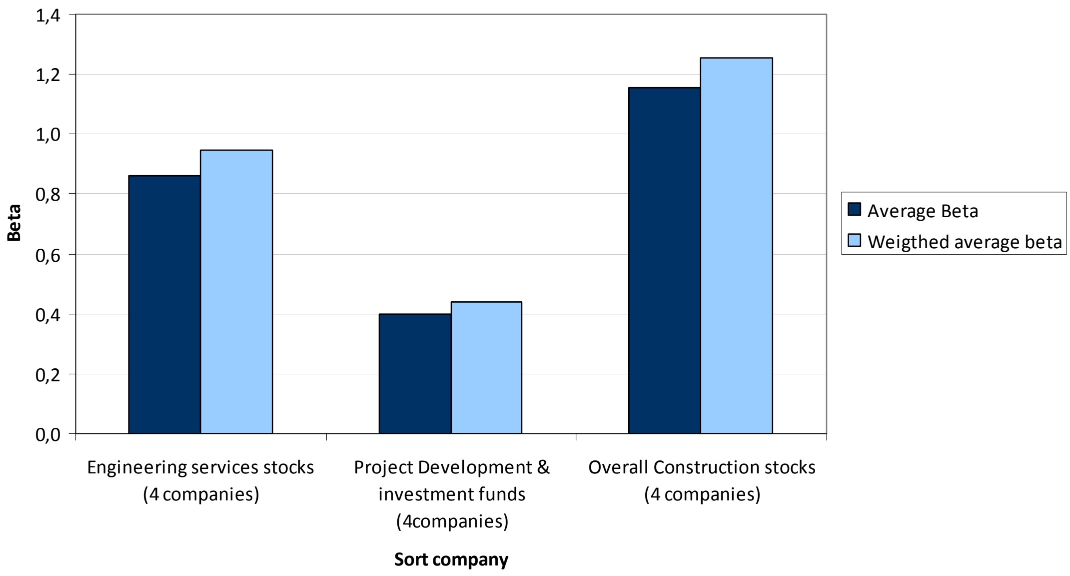
Project Development & investment stocks		
Company	Beta* 36 months	Assets 2007
Wereldhave	0,56	2.802
Unibail Rodamco	0,47	25.500
Corio	0,34	6.703
Eurocommercial Properties	0,23	2.268
Average	0,40	
Weigthed average	0,44	

* source: Thomson ONE banker; datastream

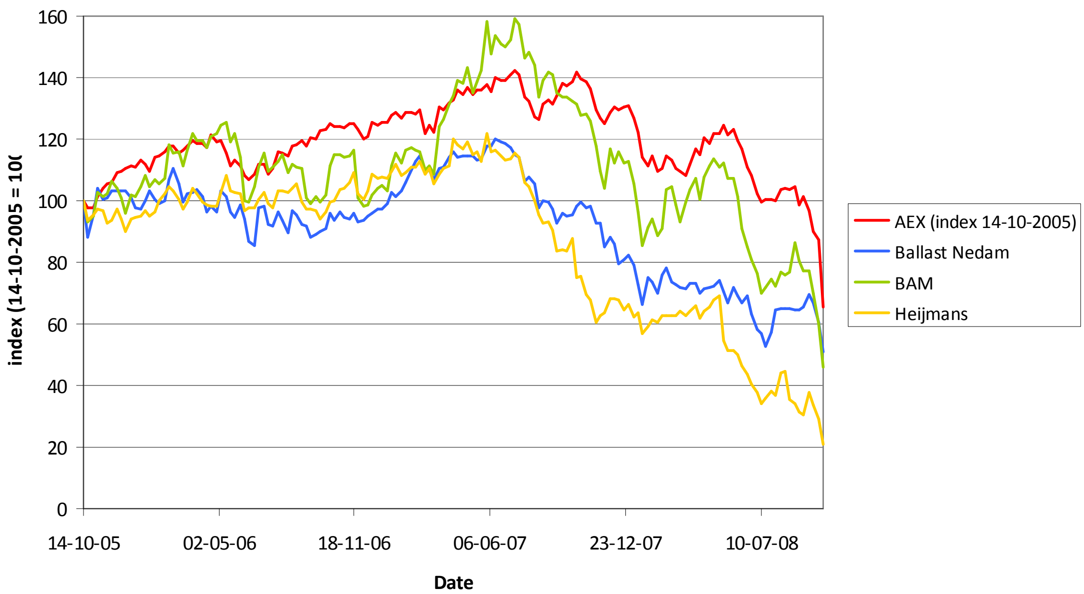
Overall Construction stocks		
Company	Beta* 36 months	Revenues 2007
Koninklijke BAM	1,41	8.954
Royal Boskalis	1,18	1.868
Heijmans**	0,98	3.732
Ballast Nedam**	1,06	1.299
Average	1,16	
Weigthed average	1,25	

* source: Thomson ONE banker; datastream
** source: Thomson ONE banker; worldscope

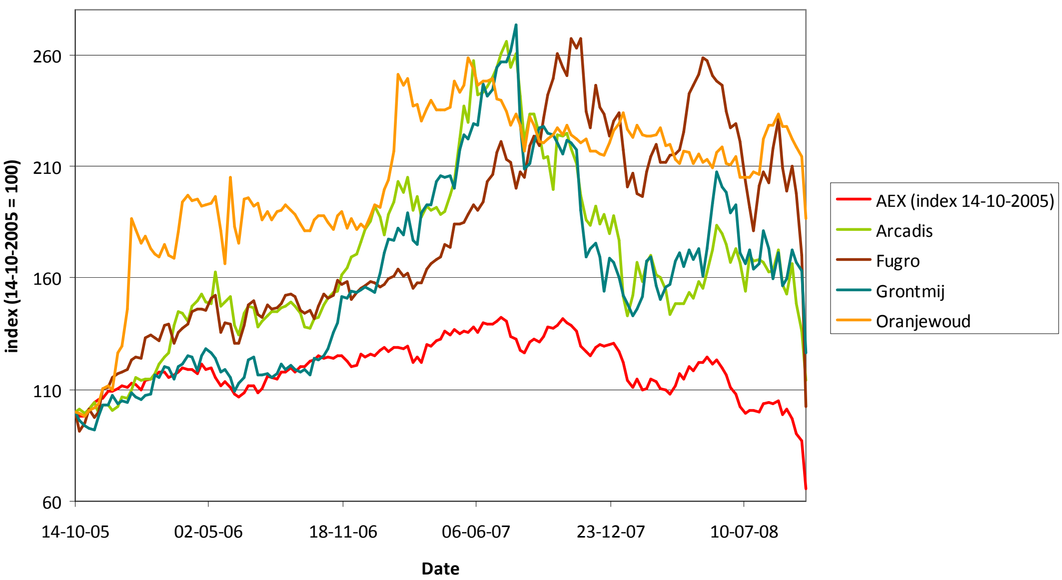
Average beta of companies per activity (listed on the Amsterdam stock exchange)



Overall construction stocks and AEX



Engineering services stocks and AEX



Real estate development and investment funds stocks and AEX