Research on the Private-side Project Selection Decision Making for Public-Private Partnership Projects

Master Thesis
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Research on the Private-side Project Selection Decision Making for Public-Private Partnership Projects

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Cover picture: A15 MaVa – Botlek Bridge
Acknowledgments

The thesis forms a major part and the final result of my Master study of Construction Management and Engineering at TU Delft. Since starting the thesis in February, I have been constantly imaging the day when I come to the final stage and I thought I would feel nothing but joy. Now eight months have passed and here is the moment, I find all sorts of feelings are welling up in my heart: proud of myself, gratitude to my supervisors, friends, and families, and longing for the new chapter of my life…

Here I would like to give my gratitude to all the people who gave me help and support during my Master study, especially the 8-month research process:

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The thesis rounds-off my two-year study here in the Netherlands, which also marks the end of my life as a student and hopefully the start as an engineer, a consultant, or a researcher perhaps. Anyhow, the past two years in Delft and what I have learned and experienced here are precious to me.

Now it’s time to move on.

Delft, September 15, 2011

Xinyi Yuan
**Summary**

**Motivation**

Innovative collaboration forms has been gradually introduced and adopted in the construction industry out of the expectation of achieving higher efficiency and more added values. Public-Private Partnership (PPP) is one of the innovative collaboration forms, which attracts the attention of both the researchers and practitioners.

The Dutch State Government is bringing a substantial amount of PPP projects to the transport infrastructure sector based on the Design-Build-Finance-Maintain (DBFM) contract form. In addition to the need to secure market share and keep work flows at a more constant level, these projects are attractive to large construction corporation groups because of possible additional business scope and multiple profit sources. By nature, large contractor corporations have the capacity to carry out the construction and maintenance works. As a result of these new contract types, they now also have to cope with two new roles, namely the one of an equity investor and the one as a maintenance contractor role.

Due to resource limitations and high transaction costs while tendering for these contracts, a construction company is not necessary to or able to bid each and every up-coming project. Therefore, it is necessary to select only those projects that are of maximum interest to the company. Before entering and during the bidding process, questions such as “Which of the up-coming projects we should bid?”, “What are the risks and how is the pay-off?” and “Whether we should stick to our choices?” are typical questions of decision makers at project and board level.

This project selection decision making is a continuous process interrelated with the pre-qualification- and bidding process. It starts from prioritizing up-coming projects during the early phase with consideration of multiple aspects, and proceeds to a go/no-go decision of a single particular project at the later stage where project risks and pay-off are the focus. Moreover, within Dutch construction corporation groups, it is often the case that different subsidiaries will execute the real construction and maintenance works, while the company at group concern level commits the equity investment. This leads to a situation that for one project, multiple decision makers are involved with different roles of interest that all have to be integrated to a balanced choice of delivering a final bid.

**Objective and research questions**

In order to arrive at justified answers to the questions regarding DBFM project selection as mentioned above, the following research objective is formulated:

To develop a project evaluation framework that supports construction companies in their PPP project selection decision making process integrating the perspectives of the equity investor and the construction and maintenance contractors involved.

In order to realize this research objective step by step, the following three research questions and sub-goals are stated:

- What project selection methods do currently exist and which of these are appropriate and applicable for PPP project selection decision making within the contractor industry?
- During this decision making process, how can risks and uncertainties be considered and how can these be quantitatively justified?
- How can the interests of different decision making parties involved be incorporated into the framework taking into account the specific focus during each phase of the bidding process?

**Literature Background**

Extensive literature studies on the above three research questions are carried out, which form the basis for the framework development.

Financial/economic analysis, multi-criteria analysis (MCA) and portfolio selection are identified as three main categories of project evaluation methods that can be used to assist project selection. After making comparisons and selection with consideration of the characteristics of the DBFM project selection decision making process from the perspective of construction companies, it is proposed that MCA can be applied during the early stage, i.e. before the pre-qualification phase, because it can deal with both qualitative and quantitative information, while financial/economic analysis can be applied during the dialogue and the final bid submission phases.

There are multiple ways that risks and uncertainties can be considered in project selection and evaluation either qualitatively or quantitatively. With respect to the two project selection methods selected above, risks and uncertainties can be incorporated qualitatively by being taken as a criterion in MCA measured by conducting qualitative risk analysis, or by applying sensitivity analysis in financial/economic analysis. Quantitative risk analysis can be incorporated in financial/economic analysis by applying risk-adjusted methods, which will lead to evaluation results of expected project return and other financial KPIs. These results can be integrated with the decision makers’ preferences and risk attitudes by applying the utility theory.

In terms of reflecting and incorporating the perspectives of different decision making parties in DBFM project selection, it can be made possible by forming a balanced decision group when applying MCA. During the later phase, as mentioned above, the application of utility function can link the evaluation results of project financial return to the decision makers’ risk attitude and therefore reflect decision makers’ interpretations of the results.

**Deliverables**

A two-part conceptual framework is developed based on the answers to the research questions. The first part of the framework, the so-called project screening part, follows the general approach of MCA. The main goal is to prioritize up-coming DBFM projects according to the company’s interests, justifying which of the alternatives are more attractive. It is proposed to form a balanced decision group to structure a set of criteria covering different perspectives and interests. The different views of decision makers will also be expressed in the criteria weights and the scores given to each alternative against the criteria. By considering the priorities of the decision makers, individual perspectives will be aggregated into a group view.

The second part of the framework is established under the assumption that the company has decided to bid for a certain DBFM project and has started to develop this bid. The aim of this part of the framework is to evaluate how the current bid and project plan will work out under risk and uncertainty and whether it can generate satisfactory financial benefit. For this, financial analysis will be adopted as the approach to evaluate the financial project return. Quantitative risk analysis is to be incorporated
into the financial analysis using the risk-adjusted cost, revenue inputs and cash flows to simulate the expected project return under uncertainty. Finally, this will be further linked to decision makers’ utility functions to find out what the uncertain pay-off means to different decision makers. In the following Figure 1 this two-part conceptual framework is depicted schematically.

Results from a framework practice

The project evaluation framework as presented in this thesis was applied to support the decision making on selecting DBFM project biddings within VolkerInfra PPP and its participating subsidiaries. A specific decision group at VolkerInfra level\(^1\) was formed and each of the members was interviewed. The results of the approach within this framework show that it can provide more justified information to assist the tender decision making process.

On applying the project screening part of this framework, nine DBFM tenders were taken as a case study. Based on an evaluation of their individual performances against different criteria and decision makers’ preferences, among these nine alternatives, the A15 MaVa and SAA A1/A6 were identified as the two highest interests for VolkerInfra, while the Groningen RegioTram project was ranked lowest. The first two projects are basically ranked high due to their favorable ratio of project size vs. transaction cost, including their challenging technical complexity. The Groningen RegioTram project has primarily a low rank because of its relatively small size with a risk full and too broad scope that

\(^1\) Within the scope of this practice, there was no room yet to include decision makers at Board and or statutory management level.
includes rolling stock operations. There is also a project identified with a relatively low rank that is currently in the bidding phase, which is the N33. The analysis showed that the N33 has a relatively small project size with a low project complexity. Therefore the ratio of project size vs. the transaction costs of this project is high. However, this project could still be a good choice considering that VolkerInfra needs to grow its order backlog.

The second part of the presented framework was applied to the A15 MaVa project. An already delivered bid was simplified and used as a case for evaluation. Different decision makers’ utility functions of project expected pay-off were structured covering their specific an individual interests within the scope of this practice. The results show that, the expected pay-off generated by the project plan and pricing strategy can be adequate to the construction contractor, but can be less favorable for the maintenance and investment parties involved. The sensitivity analysis results of this practice suggest that for the maintenance part, reducing cost, preventing subcontractors from default and increasing the profit markup and contingency amount in the O&M bid could lead to a more satisfactory return. While for the investment part, lower EPC bid price and higher percentage debt can result in higher return. The results of this practice might substantially differ if another set of utility functions, expressing a more reliable sample of an integrated decision maker’s chain, will be taking into account.

Conclusions

Conclusions regarding to the approach proposed in the framework in terms of their applicability can be drawn from the framework practice. In general the framework is found to be applicable and can provide more justified information to support DBFM project selection decision making.

- Conclusions on the application of project selection methods in DBFM project selection
  - MCA is an applicable approach before pre-qualification because it can be accustomed to a decision situation lacks quantitative information.
  - Financial/economic analysis is applicable during dialogue and final bid submission phases.

- Conclusions on the consideration of risks and uncertainties in DBFM project selection
  - In the early phase risk quantification is hardly possible and even conducting quantitative risk analysis is difficult. When applying MCA in the early phase, consideration of risks can somehow be reflected in some other criteria (e.g. in the framework practice part I, consideration of risks was reflected in “scope conformity” and “project complexity”). As the bid gets developed gradually, risks and uncertainties can be quantified by using probabilistic approach and can be linked to project pay-off straightforwardly by applying risk-adjusted cost/cash flow method to financial/economic analysis. Simulation techniques make it feasible.
  - Structuring utility functions can integrate decision makers’ risk attitudes and the evaluation results of project return.
  - Conducting sensitivity analysis can provide more insight to the problem.

- Conclusions on the incorporation of multiple interests in DBFM project selection
- By applying MCA in a group decision environment different decision makers’ interest and perspectives can be taken into account. Through appropriate aggregation, individual views can be all incorporated to derive a group view.

- The application of utility functions can make decision makers’ interpretations of uncertain project pay-off become clearer and therefore can reflect different perspectives.

Recommendations

- **General recommendations**
  - It is recommended to consider all the three roles’ perspectives when making DBFM project evaluation, which can help to get an overall picture of the project and provide more information for the decision making.

  - It is recommended to apply the conceptual framework developed in this thesis in practice and further improve it. It needs to be noticed that the framework can only provide information to assist decision making and cannot replace decision makers. In the framework practice made in this study, only a limited number of project-level decision makers were involved in the decision group. It would also be interesting to see what results will be generated if the views of the board-level and statutory management-level decision makers are incorporated.

  - The framework developed in this thesis tries to support decision making by integrating evaluation results with decision makers’ preferences and risk attitudes, which can be influenced by their previous and typical experience. The framework treats this information implicitly in alternative scoring and the utility function structuring. Therefore it is recommended to pay attention to the possible bias caused by previous experience and try to learn from the past in a rational way.

- **Recommendations on the framework practice part I – project screening**
  - It is recommended to apply this part of framework before the pre-qualification phase because it can establish a rational basis for prioritizing alternative projects. Updating of the inputs and further improvement of the proposed approach are needed.

  - It is recommended to organize structured and objective group discussion among the decision makers to arrive at consensus of criteria selection and weights assignment.

  - The recommendations on the utilization of the results are:
    - Consider bidding projects having higher ranks;
    - Consider bidding projects having lower ranks but improvement is possible;
    - When the company needs to grow its order backlog and there are no other better opportunities at hand, consider bidding projects having lower ranks due to lack of challenge;
    - Consider not bidding projects having lower ranks because they are too challenging and yet mitigation is not possible.
Recommendations on the framework practice part II – individual project evaluation

- As for the individual project evaluation part of the framework, it is recommended to apply it in the dialogue and the bid submission phases to compare different project plans or different bidding and pricing strategies.

- In order to make justifiable estimate of risks and uncertainties, it is recommended to consult experts and establish a project database documenting information such as estimates and actual performance during execution and implementation. It is also recommended to carry out sensitivity analysis to identify the key influencing factors that should be focused on.

- It is recommended to apply the utility theory, which makes decision makers’ interpretations of uncertain project pay-off become clear by structuring utility functions.

- The recommendations on the utilization of the results are:
  - If the current project plan/bid can generate high utility to all three roles, consider adopt it and seek further optimization;
  - If the current project plan/bid can generate high utility to one or two roles but low utility to the others, consider discussion and negotiation to see if trade-off can be made to arrive more preferable outcome;
  - If the current project plan/bid generates low utility to all three roles, then the project plan, the bidding and pricing strategy need to be re-examined to seek improvement.

Some more practical recommendations on the application of the framework are given in Chapter 11.2.1 in detail. In addition to the practical recommendations, recommendations to future work can be found in Chapter 11.2.2.
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VII
Section I Introduction

Results of a general background study of Public-Private Partnership (PPP) with the focus on the Dutch DBFM transport infrastructure projects are presented, followed by the problem description, research design and thesis layout.
1 Background: Public-Private Partnerships (PPP)

A background study about PPP was carried out. The aims are to get better understanding of the PPP concept and its implementation in practice. As will be explained in this chapter, the definition of PPP and the contractual models adopted vary from country to country. The focus of this thesis limits to the Dutch PPP transport infrastructure projects, which constitutes the second part of the background study.

In this chapter, first of all, some general knowledge about PPP including the definition, general characteristics and an overview of PPP models will be introduced. Secondly, the implementation experience of PPP in the worldwide and European context will be briefly described. Furthermore, the Dutch experience with PPP in the transport infrastructure sector including the basic model, major actors involved and the reasons why PPP is attractive will be introduced and explained.

1.1 What is PPP?

1.1.1 General knowledge about PPP

1.1.1.1 Definition and characteristics

Broadly speaking, PPP is an alternative to traditional public-sector procurement, which brings the public and the private sectors together in a long-term partnership for mutual benefit. In the infrastructure sector, the long-term cooperation defined by PPP can cover part of or the whole process of the planning, construction and/or exploitation of infrastructural facilities, where the risks, costs, benefits, resources and responsibilities are shared.

However, in practice, different countries have their own specific perceptions of PPP relating to their own application situations. For instance, in the United States, PPP is defined as a contractual relationship developed between the public and the private sectors and PPP projects usually involve renovation, construction, operation and maintenance of the facilities. The ownership of the facility remains in the public sector and to some extent the private party may have freedom to decide how to carry out the project.

United Kingdom is more accustomed with the term Public Finance Initiative (PFI), which is similar to the US definition but focuses more on raising funds from the private sector. While in Canadian context, PPP (often referred to as “P3”) is defined as a cooperative venture between the public and the private sectors and the emphasis is laid on the realization of the public service and the risk transfer from the public sector towards the private sector, which are seen as the two major necessary conditions for forming PPP.

Although it seems that the term ‘public-private partnership’ has not been clearly defined yet, some general characteristics of PPP can be concluded from the various definitions, which also help to understand the meaning of PPP and distinguish it as a form of strategic collaboration from traditional public-sector procurement. The main characteristics of PPP are concluded as follows:

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2 HM Treasury 2000  
3 Klijn and Teisman 2000; Koppenjan 2005  
4 United States Department of Transportation 2004  
5 National Audit Office 2009  
6 The Canadian Council for Public-Private Partnerships 2005
• At least one public party and one private party should participate in the project;7
• A long-term durable contractual relationship (up to 30 years or more) will be established;8
• The public sector party only specifies the desired output instead of detailed specifications of how to achieve it;9
• The private party is supposed to be responsible for part of or the whole process including the design, construction, finance, maintenance and/or operation of new facilities or major upgrading of existing facilities;10
• Each of the participants brings something to the project and is capable of bargaining on its own behalf;11
• The responsibilities, risks, resources, costs and benefits are shared between the two parties;12
• The private actor will be paid over the life of the contract by the users based on the user payment principle, or by the public authority based on the availability payment principle or in combination with subsidy;13 and
• The ownership of the facility should remain within the public sector all the time or at least be transferred to the public sector party after the expiry of the contract;14

1.1.1.2 Overview of PPP models

Table 1 A spectrum of public-private partnership models15

<table>
<thead>
<tr>
<th>Fully public sector</th>
<th>Public-private partnership</th>
<th>Fully private sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Build Maintain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public service provision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive private involvement Government bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a. DBFM/O Government defines the project</td>
<td>2b. BOT Private party develops the project</td>
<td></td>
</tr>
</tbody>
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The table above presents an overview of PPP models existing in practice and distinguishes them from traditional public contracting and privatization. Similar to the definition, the PPP models that are adopted also vary from countries to countries. In this thesis, the focus will be laid on the Dutch PPP model applied in the transport infrastructure sector, which is the DBFM(O) model and it will be explained in detail later on in this chapter. For explanations of other models, please refer to the literature study in Appendix I.

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7 Li and Akintoye 2003
8 Li and Akintoye 2003; Yescombe 2007; United Nations Economic Commission for Europe 2008
9 European PPP Expertise Centre 2010
10 Yescombe 2007
11 Li and Akintoye 2003
12 Li and Akintoye 2003; United States Department of Transportation 2004; Koppenjan 2005; European PPP Expertise Centre 2010
13 Yescombe 2007
14 Yescombe 2007
15 Source: Koppenjan 2008 (adapted from Bennet et al, 2000)
1.1.2  PPP in practice

1.1.2.1  Worldwide PPP experience

The practice of cooperation between the public and the private sector to deliver and improve public service is not new but has existed for centuries in the worldwide context.\textsuperscript{16} PPP has been applied globally in different sectors such as healthcare, education, social infrastructure, water and energy facilities, and transport infrastructure, etc.

Australia, United States, and developed countries in Europe headed by the United Kingdom are considered to have longer history and more mature experience of PPP implementation.\textsuperscript{17} According to a research carried out by Deloitte in 2006, PPP markets in Australia and the UK are regarded to be in the most advanced stage in terms of maturity, where more innovative partnership models and flexible approaches are being developed. Most of the developed countries belong to the second stage, where the application of PPP has been expanded to multiple sectors.

Besides the application in developed countries, PPP has also been introduced to developing countries, which is mainly implemented in the infrastructure sector including energy, telecom, transport, water and sewerage. The PPP market in developing countries remains in the start stage, where institutional framework requires improvement and PP models need to be refined.\textsuperscript{18} According to the World Bank, Brazil, China, India, Mexico and Russia are the five developing countries that have the highest level of PPP implementation both in terms of the amount of capital investment and the number of new projects launched.\textsuperscript{19}

1.1.2.2  The European PPP market\textsuperscript{20}

According to the latest market review prepared by the European PPP Expertise Centre, in the European market, the total value of PPP transactions reached EUR 25 to 30 billion during 2005 to 2007, and then declined sharply to about EUR 15 billion in 2009. However, the year 2010 shows a clear improvement and the market seems to get warmed up again.

Although a sharp decline in deal flow can be noticed during the past three years, the UK remains to be the most active market, followed by Spain, Portugal and France. Most of the European countries launched PPP deals of average or large sizes (more than EUR 90 million per deal), while PPP deals in the UK, Germany and France are of smaller sizes. 9\% of the deals signed in 2010 were of a value in excess of EUR 500 million, including two projects in Portugal, one each in Belgium, Spain, the Netherlands, France, the UK and Sweden respectively.

In European countries, PPP has been applied in infrastructure sectors including transport, public safety, environment, healthcare, education and telecoms. The transport infrastructure sector has stayed active, including roads, railways, street lighting, trams and light rails. In Italy, about 75\% of transport infrastructure projects have been carried out as PPPs.\textsuperscript{21} While in the UK, PPP projects in the transport infrastructure sector have contributed about 50\% of the total PFI/PPP project capital value.\textsuperscript{22} In 2010,

\textsuperscript{16} Moulton and Anheier 2000; Li and Akintoye 2003; Yescombe 2007
\textsuperscript{17} Li and Akintoye 2003
\textsuperscript{18} Deloitte 2006
\textsuperscript{19} World Bank 2009
\textsuperscript{20} Main source: Kappeler and Nemoz 2010; European PPP Expertise Centre 2011
\textsuperscript{21} Deloitte 2006
\textsuperscript{22} Deloitte 2006; PartnershipsUK 2010
in the European PPP market, 112 PPP transactions reached financial close of a total value of EUR 18.3 billion, in which 24 deals are in the transport infrastructure sector, which achieved the highest value in comparison with other sectors.

1.2 PPP and Dutch Transport Infrastructure Sector

1.2.1 PPP in the Netherlands

In 1986 PPP attracted the attention of the Dutch government for the first time, and the implementation of PPP started from 1990. 23 Most Dutch PPP projects are transport, housing and area development projects, which follow different models. Research shows that nearly 50% of Dutch PPP projects are in the transport infrastructure sector. 24 Significant examples include the HSL-Zuid, the Westerschelde tunnel, A59, N31, the Second Coen tunnel, and so on. The following box presents a brief introduction of a Dutch landmark PPP transport project, the Infraprovider part of the HSL-Zuid project, which can be considered as a success in terms of the implementation of PPP.

Box 1 Dutch landmark PPP project: HSL-South

HSL-South (Dutch: HSL-Zuid) is a 125-km-long high speed railway line in the Netherlands to the Belgian border. Until now it is still the biggest passenger railway project ever undertaken in the Netherlands.

Innovative contracting forms were used in this project. To realize the superstructure, a EUR 2.6 billion DBFM agreement of 25-year operation period in addition to the construction period was signed between the Dutch State government and the Project Company, Infraspeed. The Project Company is paid based on availability of the facility by the public authority. The train operation is tendered separately in the form of a 15-year concession where the major shareholder is the Dutch National Railway (NS). Several D&C contracts were used to realize the substructures. The size of the project makes it a landmark PPP project in the Netherlands as well as in the Europe.

During the planning and procurement stage, it was expected to achieve 5% cost reduction in comparison to traditional public procurement, 25 which remains to be validated with the actual performance. Although during the procurement process, a lot of negotiation and effort has been devoted to achieve private involvement at reasonable cost, and the substructures and integration turned to be problematic during execution, the implementation of PPP in this project is regarded as a success by the government. 26

The implementation of PPP in the Dutch transport infrastructure sector can be difficult and problematic. For instance, in the Betuwe line freight rail project, the attempt to introduce private involvement ended as a failure, and in the HSL-Zuid project, the organization and implementation of PPP also went through a painful process despite the outcome is considered to be a success. 27 Moreover, although the government adopts PPP procurement with the expectation to achieve the possible cost reduction and added value estimated, some past experiences reveal that this is not always the case. For instance, as one of the first-launched PPP projects in the Netherlands, the Wijker tunnel now turned out to cost more than traditionally-procured similar projects. 28

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23 Klijn 2009
24 Klijn 2009
25 Wilden 2004
26 Koppenjan and Leijten 2005
27 Koppenjan and Leijten 2005
28 Klijn 2009
Currently, PPP is still attractive to both practitioners and researchers in the Netherlands. Some researchers have been trying to explore the success factors for PPP implementation and the appropriate PPP models for projects in the Dutch infrastructure sector. While the Dutch State government is preparing to bring a pipeline of PPP transport infrastructure projects to the market, most of which are road construction and maintenance projects.

1.2.2 DBFM(O) – the Dutch PPP model

DBFM(O) is the PPP model that has been used most frequently by the Dutch government. When adopting the DBFM(O) model, the public authority usually defines the project, specifies the desired outputs and specifications. Sometimes rough design could possibly be done by the public authority. As can be seen from the figure below, the private party is responsible for design, build, finance, maintenance and/or operation. The ownership of the facility always remains in the public-sector side.

![DBFM(O) and project life cycle](image)

1.2.2.1 Project finance and contractual setup

Project finance is usually adopted as the financing technique for DBFM(O) projects. That is to say, the project will be financed based on the cash flows the project generates instead of recourse to the company balance sheets of the sponsors and executors. A Project Company (also called Special Purpose Vehicle, SPV, or Special Purpose Company, SPC) composed of the private sector actors will be established especially for this certain project.

The capital structure of the Project Company is highly leveraged. Usually c. 90% of funding required will be provided by lenders in the form of long-term limited recourse loans. The remainder c. 10% will be the equity investment and shareholder loan provided by shareholders of the Project Company.

Lenders and shareholders often require the Project Company to allocate the project technical risks elsewhere to ensure the repayment of loans, interest payments and payment of dividend, which leads to the following typical contractual setup for DBFM(O) projects (see Figure 3).

First of all, a DBFM(O) agreement will be signed between the public authority and the Project Company. The tasks and risks will be flowed downwards by signing back-to-back contracts with construction and maintenance contractors. The turnkey or Engineering, Procurement and Construction contract (EPC) and Operation & Maintenance contract (O&M) are often used as the form of the back-to-back contracts. Works can be further subcontracted. Shareholder agreements will be signed to clarify the amount of equity and shareholder loan provided by the shareholders. Accordingly, lenders also need to specify the debt terms and amount they provided to the Project Company. Interface contract will be signed to regulate the interface between construction and maintenance. Last but not least, typically a Direct Agreement will be signed between the public authority and the lenders, which provides the lenders with the right to step in when the Project Company defaults or bankrupts.

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29 Rijkswaterstaat 2009
30 Yescombe 2007
1.2.2.2 Payment mechanism

Generally speaking, in the DBFM(O) model, the Project Company can be paid by three means, namely by the availability payment from the government, user payment from public users, or government subsidies. In a PPP project, one of the three payment sources or a combination of the three can be chosen.

In the Dutch transport infrastructure sector, all three ways of payment have been adopted. For instance, in the HSL-Zuid and the Westerscheldt tunnel projects, the infrastructure providers are being paid periodically by the public authority as pre-agreed based on the availability of the facility, while the service operation providers are being paid by the public users plus government subsidies.

For road projects, it is typical for the Project Company to get paid during the operation period by the public authority based on the availability of the facility. As payment usually only starts during the operation phase, the SPC will need to attract bank funding in order to pay the construction contractor during the construction phase. Availability deduction will incur when the facility is not available or in poor quality, for instance, motorway lanes get closed or cannot handle the traffic flow to provide the required accessibility specified by the public authority in the agreement. Substandard performances such as unsafe maintenance practices could also lead to payment deduction.

Large-scale projects that require large amount of funding would increase the difficulty to realize private financing. In order to make the project become bankable and more attractive to lenders, public capital contributions can be provided in the form of lump sum payment on the pre-agreed key availability dates during the construction period, which is a typical feature of the Dutch DBFM(O) model. It could be argued that by introducing lump sum payments, the project could become similar to the traditional public sector procurement projects, therefore the amount of the lump sum payments is usually limited to no more than 50% of the total funding amount, which preserves the basic idea of PPP to introduce private financing. However, in the most recent Dutch DBFM scheme, the N33 project, the lump sum payment has been reduced to a very small amount. Figure 4 shows the typical payment mechanism used in the Dutch DBFM(O) model.
1.2.3 Actors and their motivations

1.2.3.1 The government

Usually the government is the initiator of PPP projects. The government is responsible for initiation, planning and procurement in the early phase of the project. If the project is availability payment-based, the government should also commit payment as agreed in the contract during the project execution and operation period. Specific to the Dutch situation, the State government and the Road Directorate (Rijkswaterstaat) usually play the role of the public authority. Provincial government and local municipalities may also launch PPP projects.

Generally speaking, to the public side, the motivation for PPP mainly comes from the possibility of delivering better value and relieving the financial burden to some extent, which also applies to the Dutch situation. There are three main reasons for the Dutch government to be interested in PPP, namely the possibility to deliver less expensive projects, to relieve the financial burden, and to increase project quality, which is often referred to “Value for Money”.

First of all, when it is possible to achieve the outcome of better value at less cost, PPP will be preferred. Tools such as Public Private Comparator (PPC) and Public Sector Comparator (PSC) are designed to make comparison of plans in the planning phase and evaluation of bids during procurement process. It is also believed that the private sector actors perform better in cost reduction and their project management experience can contribute to the public sector projects delivery.

Secondly, procuring projects in DBFM agreement is a way to deliver infrastructure facilities in the situation that no sufficient budget is available at hand immediately. As showed in Figure 5, different from traditional public sponsored projects, the government will pay for the project by spreading the payment over a long period of time, which relieves the financial burden and may increase the efficient use of the budget.

Last but not least, the consortium itself could become a “quality driver” and deliver the project of better value. It is often the case that the project executors (i.e. the EPC and O&M contractors) are also shareholders of the Project Company (refer to Chapter 1.2.3.2), which stimulates them to seek

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31 Koppenjan 2008; Mu 2008; United Nations Economic Commission for Europe 2008
32 Interview – Mr. J.G. Schillemans
optimization and innovation. Besides, the integration between design, construction and maintenance could also increase the possibility for innovation and optimization.

1.2.3.2 Construction companies

In DBFM(O) projects construction companies can be industrial investors of the Project Company or simply participate in the project as EPC, O&M contractors or subcontractors. The term “industrial investor” refers to those companies who commit investment as a strategy in order to ensure their participation in the construction and maintenance works. These companies are also often referred to as sponsors because they have various roles in one project. When a construction company participates in a DBFM(O) project as an industrial investor, which is often the case, it plays not merely the role of a construction contractor as usual in non-PPP projects, but also an investor role.

In addition, DBFM(O) projects offer the construction company the opportunity to expand their business scope by broadening the value chain of the traditional construction contractor, by which we mean that construction companies do not have to limit themselves within the scope of design and construction, but also maintenance and integral life cycle project and asset management. Therefore construction companies get the third role of a maintenance contractor in DBFM(O) projects.

In the Dutch transport infrastructure sector, it is typical to see large construction corporation groups in DBFM(O) project bidding. By aggregating the expertise and resources that owned by subsidiary companies who specialize in construction, maintenance and project management, large construction corporation group can handle all the three roles. Dutch large contractors such as BAM and VolkerWessels also have established branches or teams with specific focus on PPP project tendering and management.

Another kind of players often seen in the competition is companies that are more of a general contractor character (e.g. Fluor). These companies do not have workforce to carry out the construction and maintenance work by themselves, but are equipped with extensive project management expertise, therefore they usually participate in DBFM(O) projects at the Project Company level and form a consortium together with other specialized construction companies.

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33 Yescombe 2007
The motivation of construction companies mainly comes from business scope expansion, multiple profit sources and room for innovation. Including maintenance in the project scope offers more possibility and flexibility for the construction companies to allocate resources optimally, achieve innovation and then realize cost reduction and life cycle optimization. Besides, profit can be obtained from the investment, the construction as well as the maintenance work, which is also appealing.

1.2.3.3 Financial institutions

Financial institutions involved in Dutch DBFM(O) transport infrastructure projects include banks, equity investment funds and insurance companies. Banks and equity investment funds can be shareholders of the Project Company. Different from industrial investors, when being investors of the Project Company, banks and equity investment funds only commit an equity investment but have no interest in carrying out the construction or maintenance work. Nowadays banks are more often play the role of a lender, i.e. a senior debt provider, in DBFM(O) projects instead of an equity investor due to capital constraints. Insurance companies provide insurance services to construction companies and other financial institutions.

To financial institutions, DBFM(O) projects are investment opportunities. Banks and investment funds can decide whether to step into the project in the very beginning as a member of the bidding consortium with construction companies, or participate in later after bid submission. They can also opt to be secondary investor and purchase shares from primary investors, e.g. after the completion of the construction work. The motivation of financial institutions to participate in Dutch DBFM(O) projects would be the relatively low investment risk because the government is the project initiator and the Project Company income source largely comes from the government.
2 Problem Description and Research Design

There are different actors in the private sector involved in a PPP project. This thesis will focus on construction companies’ PPP project selection. Chapter 2.1 first explains the reason why construction companies’ PPP project selection is of interest to be researched, and then defines the scope and specifies the features, which leads to the problem description (see Chapter 2.2). In Chapter 2.3 the research scope and objective will be specified, and the research questions will be posed. Last but not least, the thesis layout will be introduced in accordance with the research framework.

2.1 Construction companies’ PPP project selection decision

We learned from the background study that in PPP projects adopting the DBFM or similar contract forms, the public authority, construction companies and financial institutions are major players. In terms of project selection, much effort has already been devoted to the public side choice of PPP projects, i.e. whether a project should be procured as PPP or not, and decision support tools such as the PPC and PSC have been developed. To financial institutions, PPP projects are investment opportunities, and investment appraisal is also a discipline where mature theories and methods have been developed. On the contrary, it seems that less attention has been paid to construction companies and their role transformation. Therefore in this thesis the private-side PPP project selection will focus on the construction companies’ perspectives.

PPP projects not only provide construction companies with the opportunity to do integral projects, but also require construction companies to step into long-term commitments with certain amount of investment. High cost in terms of both time and resources will be incurred when bidding PPP projects. Construction companies cannot always bid every PPP project coming to the market and only projects that are more attractive and achievable should be preferred; therefore construction companies need to make their choices among various PPP projects. In the Dutch transport infrastructure sector, the tendency for the government to bring more DBFM projects into the market makes the research meaningful and necessary.

It can be seen from the above mentioned major actors that construction companies are of significant importance to realize PPP projects and they may have a triple role of a construction contractor, a maintenance contractor, as well as an investor, which is different from non-PPP projects and is more interesting. To be more specific, the thesis focuses on the project selection decision in terms of DBFM projects in the transportation infrastructure sector from the perspective of large construction corporations who tend to and are able to play all the three roles.

2.1.1 The scope

Dutch construction companies get the opportunity to undertake DBFM projects through competitive bidding which typically involves more than three bidders, so the DBFM project selection decision making is interrelated with bidding decision making. Describing the process of DBFM project procurement first would be helpful to define the scope of the DBFM project selection decision problem.

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34 Refer to Appendix I
Generally speaking, bidding DBFM projects is characterized by intelligent competition among very limited competitors. Competitive dialogue is adopted as the procurement procedure in the Netherlands. The procedure begins with a pre-qualification stage where any construction companies who are interested in the project can participate. After evaluation, those who are considered to have the required technical, financial and management capacity will be invited to participate in the next dialogue phase. The dialogue phase can possibly take 1 to 1.5 years long, during which the number of bidders will be gradually limited to 3 to 5 and finally the preferred bidder will be generated.

To a construction company, the DBFM project selection decision is not a one-off point decision but a continuous process. First of all, the company needs to screen the projects that are coming up to the market in the couple of coming years and decide to participate in the pre-qualification of which of them. After getting pre-qualified, during the consultation and dialogue phase, the company can still consider whether to continue bidding the projects or pursue other opportunities. Finally the company needs to decide whether or not to submit the bid for a particular project.

In the early phase of the DBFM project selection decision process, the decision concerns comparisons and ranking among potential alternatives. As the bid getting established gradually, the decision is more of a go/no-go decision of a single particular project, and has a lot to do with the bidding and pricing strategies and decision-making.

### 2.1.2 Features

To a construction company, first of all, making DBFM project selection decisions requires consideration of multiple aspects. Although it seems reasonable to take profit maximization as the major principle for project selection, aspects such as the company’s development strategy can have more influence on the decision. Besides, the selection is always constrained by the resource limitation.

Secondly, a major part of DBFM projects is construction, and construction projects always involve risks. Furthermore, by adding a relatively long operation phase, DBFM projects are subject to more uncertainties in the future. So the risk and the uncertainty cannot be neglected during the project selection process.

Moreover, it needs to be aware of that due to the role transformation; multiple perspectives should be involved in the process. Usually large construction corporation groups have the expertise and capability to undertake DBFM projects, whose subsidiary companies will play the role of construction contractor and maintenance contractor. Usually it requires the directors of the subsidiary companies together with the corporation board members to make the project selection decision, i.e. the PPP
The project selection decision is carried out in a group decision making environment. Multiple decision makers are involved to represent the multiple roles with different objectives and interests.

Last but not least, in the early phase of the process, usually only limited information especially limited quantitative information about the projects will be available, which means potential profit can only be roughly estimated, and the risk and the uncertainty are difficult to be quantified.

2.2 Problem Description

In Dutch DBFM projects, construction companies not only play the role of a construction contractor as they are in non-PPP projects, but also the role of an investor and a maintenance contractor. In terms of the same project, the three roles would look at different parts of the project and therefore possess different perspectives. However, when making project selection, it seems that construction companies evaluate DBFM projects in the same way as they treat non-PPP projects. That is to say, it seems that when making project selection, the evaluation process lacks sufficient awareness of the role transformation and only the traditional construction contractor role plays a part. In order to make sensible project selection decisions, it is necessary to take all three roles’ perspectives into consideration.

The main problem identified can be concluded as follows:

The project selection decision making is crucial to Dutch construction companies when stepping into the PPP market, which requires establishing a decision support framework where the perspectives of the three roles can be incorporated.

2.3 Research Design

2.3.1 Research scope

The emphasis of the research will be laid on DBFM projects in the Dutch transportation infrastructure sector. The selection decision problem in question adopts the perspective of large construction corporation groups who tend to and is able to handle the three roles, namely the construction contractor role, the maintenance contractor role and the investor role.

2.3.2 Research objective

To develop a project evaluation framework that supports construction companies in their PPP project selection decision making process integrating the perspectives of the equity investor and the construction and maintenance contractors involved.

2.3.3 Research questions

- What project selection methods do currently exist and which of these are appropriate and applicable for PPP project selection decision making within the contractor industry?
- During this decision making process, how can risks and uncertainties be considered and how can these be quantitatively justified?
- How can the interests of different decision making parties involved be incorporated into the framework taking into account the specific focus during each phase of the bidding process?
2.3.4 Research Framework and Thesis Layout

Figure 8 on the right illustrates the research framework and the corresponding thesis layout. First of all, a background study on PPP with focus on the Dutch DBFM model was conducted, the aim of which is to get better understanding of the characteristics of PPP and its implementation in the Dutch transport infrastructure sector. The results of the background study can be found in Chapter 1 and Appendix I. It also helps to define the PPP project selection decision problem (Chapter 2) and limit the research scope. Then the research design is made based on the background study.

In the literature background section, project selection methods are studied first in order to select the appropriate method to be used as the basis for the PPP project selection framework (Chapter 3). Then the theory of risk analysis is also studied to see how risks and uncertainties can be incorporated in project selection (Chapter 4).

The general framework will be developed based on the selected method (Chapter 5). Then the general framework will be customized to VolkerInfra and the participating VolkerWessels subsidiary companies in the DBFM transport infrastructure project selection to see how it can be used in practice (Chapter 6, 7 and 8).

Last but not least, conclusions and recommendations will be made (Chapter 9).
Section II Literature Background

Results of literature studies on project selection methods and consideration of risks in project selection are presented in this section, which forms the basis for the development of the DBFM project evaluation framework.
3 Project Selection Methods

In order to select the projects that can best meet the organizational strategic objectives, decision-makers need to evaluate or appraise the alternatives in terms of every aspect that they care about. Therefore project selection involves evaluation or appraisal of alternative projects and project selection methods are fundamentally the same as project evaluation/appraisal methods.

In the first place, project selection methods can be distinguished into two broad categories, namely nonnumeric methods and numerical methods. Nonnumeric methods require no numerical information and the go/no-go decision of projects are derived simply based on necessity. For instance, to make the decision of building a dike to protect the city from the flood obviously requires no extensive evaluation. Another example can be the company may have no doubt in bidding several PPP projects in order to maintain its market share and competitiveness.

Numerical methods will be needed when we go a step further. Taking the competitive necessity case as an example, in the Dutch transportation infrastructure sector, there will be a pipeline of DBFM projects brought to the market, which may be more than the company can handle in terms of bidding and construction capacity. Then the company obviously needs to choose from this category of projects. In this circumstance, nonnumeric methods are not sufficient.

Our attention will be laid on numerical methods, which can be subdivided into three sub-groups of methods, namely financial/economic analysis, multi-criteria analysis, and portfolio selection. Each group of methods has its own purposes, requires different inputs, has different advantages and disadvantages, and therefore is applicable in different situations.

In this chapter, first of all, the various project selection methods will be classified and briefly introduced. Then comparisons of the methods will be done in terms of the required information, major advantages and disadvantages. Finally based on some principles of method selection concluded from the literature, the appropriate method for PPP project selection will be chosen.

3.1 Financial/Economic Analysis

Financial/economic analysis requires quantification of all sorts of effects into the monetary form, therefore also called monetary-based analysis. Financial/economic analysis can be static or based on discounted cash flow (DCF) to take the time value of money into account. In addition to time value of money, it is suggested that flexibility in a project should also be considered and real option analysis can serve for this purpose.

3.1.1 Static methods

Static methods ignore the time value of money. To evaluate the capital investment, the payback period and the average rate of return are used as the profitability indicators in the static methods. The payback period of a project is the period after which the capital invested is regained from the average cash flow surpluses generated by the project. However any costs and revenues occurring after the payback period will be completely ignored. Generally speaking decision-makers would prefer projects of shorter pay-back periods. The average rate of return is the ratio of the average annual profit (either

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35 Meredith and Mantel 2006
36 Milosevic 2003
before or after taxes) to the initial or average investment in the project. Higher average rate of return is preferred. For long-term project, static methods are not recommended for project evaluation.

Cost analysis is usually applied by construction and maintenance contractors, which also sees the project cost and income in a static way. Contractors often make rough cost estimation and compare it with the possible budget available indicated by the client. If there is acceptable chance to earn profit, the contractor would consider the project attractive in terms of profitability. Net profit margin, calculated as the net income divided by the total revenue, is often used by construction contractors as measurement of project profitability. Maintenance contractors would also find the break-even point important. 37

3.1.2 Discounted cash flow model-based methods

Methods based on discounted cash flows take time value of money into account, which is necessary for long-term project evaluation. Financial analysis, Cost-Effective Analysis (CEA) and Cost-Benefit Analysis (CBA) are typical discounted cash flow model-based methods that are widely applied. Financial analysis focuses on the cash inflows and outflows, which are the actual cost committed and revenue earned on the project. CEA considers all kinds of cost of the project and assigns monetary value to them, while CBA also assigns monetary value to all kinds of benefit in addition to the cost that a project can generate. In terms of project evaluation and selection, usually from a public viewpoint, CEA and CBA are required, while from a private viewpoint, financial analysis is usually sufficient.

The Net Present Value (NPV) and the Internal Rate of Return (IRR) are two indicators that are widely-used in these DCF-based analyses to measure project feasibility and profitability. In DCF model, all estimated future cash flows are discounted to their present value (PV). The sum of the PV of all the individual cash flows including inflows and outflows is called the net present value (NPV). As showed in the equation below, the NPV takes the amount and the timing of occurrence of the estimated cash flows and a discount rate as inputs to calculate the value a project/investment can create. The NPV rule suggests that a project can generate positive net present values is considered to be profitable and can be accepted; otherwise the project should be rejected. When comparing several projects, the one with the highest NPV is considered to be the most profitable.

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

Where:

- $CIF_t$ - Cash inflow in period $t$
- $COF_t$ - Cash outflow in period $t$
- $r$ - Discount rate
- $T$ - Total number of time periods

IRR is the uniform discount rate that makes the net present value of all cash flows of a certain project equal to zero (see the equation below). The rate of return rule indicates that investments offer rates of return in excess of their opportunity costs of capital can be acceptable. By using percentages of returns rather than euros of NPV, the IRR method provides investors with a clear and direct way of

37 Interview – Mr. R. de Ridder
comparing the profitability of projects with different sizes. However, it needs to be noticed that this method has some pitfalls. For instance, when the future net cash flows are positively and negatively alternate (e.g. -, +, +, - , +, - , - , +, - , - , +, ...), more than one internal rate of return could be obtained. Moreover, the IRR method can be misleading when applying to the appraisal of mutually exclusive projects. Usually the cash flows used to calculate the project IRR are the free cash flows. It is also possible to calculate IRR on the cash flows to equity to evaluate equity investment in the project.

\[
NPV = \sum_{t=0}^{T} \frac{CIF - COF}{(1 + IRR)^t} = 0
\]

3.1.3 Real option analysis

The DCF-based methods have been criticized of no consideration of flexibility. DCF models assume the decision maker would take no action and the project would be executed according to the original plan under original assumptions. But in practice, when confronting with risks and opportunities in a project, decision makers would choose to deal with them actively by adopting different plans or strategies.

The Real Option Analysis (ROA) is proposed to be a way to incorporate future flexibility into the project evaluation, which extends from its application in corporate finance in the form of financial option. When adopting this approach, the future possibility to change in a project are seen as options, and the project value is the sum of traditional DCF-based NPV and the value of the option. Typical real options in projects include defer, multistage, outsource, explore, lease, abandon, flexible scale and strategic growth. 38

Most successful applications of the approach have been seen in the new product development, oil exploration, and real estate development and so on. When it comes to highly uncertain projects of longer duration the real option approach may have an advantage. 39

3.2 Multi-Criteria Analysis

Financial/economic analysis can give straightforward indicators of project profitability or more generally, the project performance when all costs, revenues and benefits (if required) can be estimated in monetary form. When quantifying all the aspects that need to be considered in monetary form is not possible, Multi-Criteria Analysis (MCA) can be the method adopted for project selection.

3.2.1 Definition

MCA includes a series of methods that can support decision-making when multiple aspects of the alternatives need to be considered. Multiple criteria can conflict with each other and decision makers have to make trade-offs, which is not an easy task. MCA aims to structure the decision process under such environment more transparently. In MCA, criteria can be measured objectively if possible, or subjectively based on the interpretations of decision makers. It worth to be noted that the MCA methods aim to assist decision makers finding the alternative that best suits their objectives and their understanding of the problem instead of making the objectively “correct” decision.

38 Brealey and Myers 2003; Milosevic 2003
39 Milosevic 2003
3.2.2 General procedure

Although there are numerous MCA methods that vary from each other in detail, a general procedure of MCA can still be summarized\textsuperscript{40}, which is shown in the figure below.

![General procedures of MCA](image)

**Figure 9 General procedures of MCA\textsuperscript{41}**

1) First of all, the decision maker(s) needs to identify the alternatives, specify the aspects that he cares about and structure a set of criteria;
2) Each criterion should be comprehensive and measurable so all the alternatives can be rated on each criterion, which will generate a performance matrix;
3) The decision maker is required to express his preferences toward the consequences as well as the criteria. The former can be expressed in values/scores and the latter can be represented by weights, which will generate a value/score matrix and a weight matrix respectively; and
4) Finally the evaluation results of the alternative on each criterion need to be aggregated into a total score in order to generate the final rank.

It is also possible to use MCA methods with no values and weights, i.e. using a score card. Alternatives are simply evaluated in terms of their performance on each criterion and this performance matrix will be the end result presenting to the decision makers to assist their decisions.

3.2.3 Classification

The most widely used category of MCA methods is probably those using the weighted sum for the overall score aggregation. In these MCA methods, the general procedure of MCA described above is followed. Alternatives are evaluated one by one and the output is often in the form of a scoring model. The total score of the alternative is the weighted summation of its standardized measurement consequences obtained on each criterion.\textsuperscript{42} When the problem concerns multiple dimensions, the preferences of the decision maker toward consequences can be expressed in values. In this way, the measurement consequences of each alternative in terms of each criterion can be transformed into a common dimensionless scale. Typical methods in this category include the Simple Multi-Attribute Rating Technique (SMART) and its variants, and the Multi-Attribute Value/Utility Theory (MAVT/MAUT).

Another kind of MCA methods are based on pair-wise comparisons. That is to say, the decision makers’ preferences toward alternatives’ performances on a certain criterion are expressed in ratios by

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\textsuperscript{40} Triantaphyllou 2000
\textsuperscript{41} Chen, Kilgour et al. 2004
\textsuperscript{42} Triantaphyllou 2000
comparing the alternatives in pairs, which also solves the problem of multiple dimensions at the same time. The final outcomes are usually calculated based on the comparison matrix established by the pair-wise comparisons. Typical examples include the Analytic Hierarchy Process (AHP) and outranking methods. Obviously these methods require at least two alternatives in order to be applicable.

### 3.3 Portfolio Selection

Portfolio selection distinguishes from the project selection methods mentioned above in that it structures the decision problem in a different way. In the above mentioned methods, projects are first ranked based on financial merits using financial/economic analysis, or the overall performances in terms of all aspects that the company emphasizes using the MCA methods, and then the selection will be made from the top of the list until the resources are exhausted.

Portfolio selection takes the resource constraint and interactions among the alternatives into account when making project selection decisions. Portfolio selection essentially structures a problem of optimization. A typical decision requires portfolio selection can be formulated as: within the constraints of budget, human resources, equipment available and so on, how to select projects that can maximize pay-off? It worth to be noticed that the merit to be maximized need not necessarily to be the financial revenue. Any measure of goodness of the alternative projects will do.

Portfolio selection methods not only deals with the selection of new projects, but also the existing project portfolio, so the ongoing projects will be monitored to see if they still make contribution to the goals, otherwise resource redistribution will be considered.

### 3.4 Methods Comparison and Selection

#### 3.4.1 Method comparison

Table 2 compares the different groups of methods in terms of the required information, major advantages and disadvantages.

Financial/economic analysis requires extensive information that is quantifiable in the monetary form, for instance, usually the estimation of future costs and revenues is necessary for conducting the analysis. Methods based on discounted cash flow model are straightforward and more realistic since they consider the time value of money. By adopting the real option approach, flexibility involved in a project can be incorporated, which is however not a simple thing to achieve but require extensive expertise, data and analysis.\(^{43}\)

Generally speaking, MCA are able to deal with qualitative and quantitative data, which makes it useful in the situation where less quantitative information is available. MCA can also incorporate multiple objectives and views. The major challenges lie in how to structure the model to reflect the actual decision situation in a complete and comprehensive way, and in how to appropriately express the decision maker’s preferences.

Portfolio selection has the major advantage of considering the interaction among the alternatives, and the resource constraints. However this method requires the decision situation to possess the characteristic of an optimization problem.

\(^{43}\) Milosevic 2003
<table>
<thead>
<tr>
<th>Numerical method</th>
<th>Required information</th>
<th>Major advantages</th>
<th>Major disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial/economic</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static methods</td>
<td>Estimation of cost and revenue</td>
<td>Simple to use and understand</td>
<td>No consideration of time value of money; The pay-back period is insensitive to project size and ignore future potential</td>
</tr>
<tr>
<td>DCF-based methods</td>
<td>Estimation of cost and revenue; Select the proper discount rate</td>
<td>Easy to calculate using spreadsheet; Easily understandable and straightforward; Enable decision makers to communicate more readily about financial considerations of projects; Make it easier to compare projects with other capital investment opportunities</td>
<td>Requires extensive data about future costs and revenues; IRR takes no account of project size; IRR can have multiple answers</td>
</tr>
<tr>
<td>Real option</td>
<td>Estimation of cost and revenue; Risk analysis; Estimation of option value</td>
<td>Considering risk mitigation and management flexibility; Forces decision makers to confront risks and formulate decisions that might be taken over time</td>
<td>Requires extensive data and analysis; Requires explanation; Time-consuming to structure the project into options</td>
</tr>
<tr>
<td>Weighted sum-based</td>
<td>Measurement of alternatives’ performances on each criterion; qualitative or quantitative Decision maker’s preferences toward criteria and performances of alternatives on each criterion</td>
<td>Conceptually simple and transparent; Easy to use; Consider multiple aspects as well as objectives; Multiple viewpoints can be incorporated; Can be tailored to fit the decision situation; Can deal with both qualitative and quantitative information</td>
<td>May give impression of false precision; Requires significant input from higher management; Developing an effective scoring model can be time-consuming; Express decision makers’ preferences appropriately requires much effort</td>
</tr>
<tr>
<td>MCA</td>
<td></td>
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<tr>
<td>Pair-wise comparison-</td>
<td>Decision makers’ preferences toward criteria, and alternatives’ performances on each criterion</td>
<td>Allows criteria to be disaggregated into several levels and simplify the decision problem; Simple procedures and user friendliness; pair-wise comparison is easily understandable; Suitable for group decision-making</td>
<td>Requires extensive input from functional and higher management; Difficulty in ensuring consistency; Large number of alternatives and criteria is large will increase the number of pair-wise comparisons need to be made; Adding new alternatives or criteria, the whole process needs to be redone</td>
</tr>
<tr>
<td>based</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Portfolio selection</td>
<td>Estimation of cost and revenue; Identify optimization goals, constraints and conflicts</td>
<td>Takes into account interactions among the alternatives and resource constraints; Simple calculation for small optimization problems</td>
<td>Requires extensive data; Can become time-consuming and very complex when there are a lot of alternatives, constraints and maximization objectives</td>
</tr>
</tbody>
</table>

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Table 2 Comparisons of project selection methods

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Milosevic 2003; Meredith and Mantel 2006; Verhaeghe 2009
3.4.2 Method Selection

3.4.2.1 Method selection principles

Table 3 Methods applicability

<table>
<thead>
<tr>
<th>Numerical methods</th>
<th>MCA</th>
<th>Financial/economic analysis</th>
<th>Portfolio selection</th>
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<td>Weighted sum-based</td>
<td>Pair-wise comparison-based</td>
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<td>Multiple criteria</td>
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<td>Individual decision making</td>
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<td>✓</td>
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<tr>
<td>Group decision making</td>
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<tr>
<td>Limited quantitative information</td>
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<tr>
<td>Optimization considering resource constraints</td>
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<td>Risk and uncertainty</td>
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<td>Preference of decision makers</td>
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<td>Easily understandable concepts</td>
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<td>Simple procedures</td>
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<tr>
<td>Straightforward results</td>
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From the comparison made in the last chapter, it can be seen that it is hard to tell which of the project selection methods are superior to or more advanced than the others. Although the static methods are often considered to be too conservative and crude, they are still widely used in practice.\textsuperscript{45} The choice of project selection method depends on the characteristics of the decision problem and the preference of the decision maker.\textsuperscript{46} Table 3 compares the applicability of different methods in terms of the decision problem situation.

**Principle 1: Select the method that can reflect the decision problem appropriately.**

The method selected should be able to describe or structure the decision situation appropriately, i.e. reflect the reality to an acceptable extent. The characteristics of the project selection decision problem should be made clear.

First of all, the number of alternatives and the purpose of the decision influence the selection of methods. The decision maker needs to be sure of whether it is a go/no-go decision concerning a single project, or the aim is to prioritize a set of projects.

Secondly, the decision maker needs to specify which elements are of the most importance to him and can cause decisive impacts on his decisions. If it is sufficient to consider financial merits only, or all other aspects can be somehow measured in monetary form, financial/economic analysis would be preferred, while if other aspects especially those cannot be quantified in the monetary form should also be emphasized, MCA would be more suitable.

\textsuperscript{45} Milosevic 2003

\textsuperscript{46} Meredith and Mantel 2006
Thirdly, the availability and the quality of information can directly influence the applicability of project selection methods. MCA is suitable for the situation when there is limited quantitative information available. In other words, these methods can be utilized in the project selection decision-making in the early phase. Other methods would require estimation of future costs and revenues and even the analysis and quantification of the risk and the uncertainty.

Moreover, when the decision problem shows the characteristic of an optimization problem, portfolio selection methods can be considered. When the project can be structured into a series of possible options, the ROA can be used.

Last but not least, another element requires consideration is whether the decision is made individually or by a group of decision makers. Group decision-making involves the issue of incorporating and aggregating different viewpoints.

**Principle 2: Select the methods according to the preference of the decision maker.**

Since the project selection methods are a kind of tools that serve as assistance to decision-making, the preference of the decision maker also plays a part in the method selection. For instance, Meredith and Mental (2006) strongly favors the scoring models because they are easy to use and well adaptable to changes. Milosevic (2003) mentioned in his book that when choosing the financial/economic analysis to evaluate projects, it would be appropriate to use the method that the company has got used to. Generally speaking, decision makers are board members, and managers in companies and they may not all possess the expertise that analysts has, therefore usually methods with easily understandable concepts, simple procedures, and straightforward results will be preferred.

Besides the two principles concluded above, some other requirements such as easier computerization and lower cost for data gathering and information processing should also be ensured. And if possible, the decision model structured based on a certain method should be flexible to adapt to different time periods and various changeable situations. In addition, it worth to be noticed that the methods motioned above can be used in a combined form, for instance, the results of financial/economic analysis can be further used as inputs for MCA and portfolio selection.

### 3.4.2.2 Select the appropriate methods for PPP project selection

The characteristics of construction companies’ PPP project selection decision making concluded in Chapter 2 are as follows:

- A continuous process instead of a one-off selection;
- Limited quantitative information available during the early phase;
- Group decision making environment;
- From prioritizing multiple alternatives with consideration of multiple criteria during the early phase to go/no-go of single alternative at the later stage; and
- Risk and uncertainty play an important part.

Based on the method selection principles and comparisons of methods in terms of required information, advantages and disadvantages, and applicability, here MCA is considered to be appropriate for construction companies’ PPP project selection decision making in the early phase, i.e. before the pre-qualification. In terms of the selection of a specific MCA method, it is often said to be

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47 Meredith and Mantel 2006
a decision making paradox because itself is a MCA problem.\textsuperscript{48} Again no certain MCA method is superior to the others. Applying different MCA methods to the same decision problem would probably yield different results. The two principles are also applicable here, that is to say, the choice should be made based on the decision problem at hand and the preference of the decision maker. Here the weighted sum-based MCA will be chosen simply because of the following two main reasons: 1) it has been widely applied to solve similar decision problems concerning prioritizing alternatives such as projects, bids, design plans, etc.\textsuperscript{49} so the concept can be more easily understood; and 2) when a large number of alternatives exist, it can still preserve the simplicity. While methods based on pair-wise comparisons would require a large number of pair-wise comparisons in accordance with the number of alternatives, therefore the complexity would increase and ensuring the consistency when making comparisons will possibly become difficult.

When the selection process proceeds to a later stage, i.e. the dialogue and the final bid submission phase, where more information is available for estimating project cost, revenue, risk and uncertainty quantitatively, financial/economic analysis can be applicable. Although construction companies often need to consider their resource capacity, partnering and subcontracting makes the resource limit problem less critical. Besides, whether or not be able to achieve certain project return first depends on whether the company will or will not win the bid. Therefore portfolio selection is not considered to be applied here.

\textsuperscript{48} Triantaphyllou 2000

\textsuperscript{49} For examples please refer to Duarte and Reis 2006; Tsamboulas 2007; Cundric, Kern et al. 2008
4 Risk Analysis and Project Selection

Risks and uncertainties are elements that almost always influence project selection decision making. In an early stage of project selection, risks and uncertainties are usually difficult to be analyzed, but ultimately, these two could be decisive factors to decision making because they influence the project pay-off directly. Therefore risks and uncertainties have to be considered appropriately during the process of project selection.

In this chapter, first of all the general concept of risk and risk analysis will be introduced. Then, based on the project selection methods discussed in the previous chapter, the possible ways in literature to incorporate risk analysis into the methods will be discussed. The focus will be laid on the MCA and Financial/economic analysis. Last part of this chapter will explore the risk sources and allocation in Dutch DBFM projects.

4.1 Risk, Uncertainty and Risk Analysis

4.1.1 Definition of risk and uncertainty

Multiple definitions of risk and uncertainty can be found in the literature and there has been an ongoing debate about the definition of risk and uncertainty. One key point where debates occur is whether or not to distinguish between the risk and the uncertainty. In some literature, risk is distinguished from uncertainty in that the risk is an event with known probability of occurrence while the uncertainty is not.50 Another debating topic is whether the risk only includes negative impacts or the positive impacts as well. For instance, according to the PMBOK, project risk is defined as an uncertain event that, if it occurs, has a positive or a negative effective on project objectives such as cost, schedule and quality.51 However, in the RISMAN approach adopted in the Dutch infrastructure project management, risk is defined as an event that may or may not occur and can cause inferior influence to project objectives, for instance, higher costs, extension of project duration, failure to meet quality, information and organizational requirements, etc.52

In this thesis, the risk and the uncertainty will not be strictly distinguished from each other, and both the down-side and upper-side impacts will be taken into account. Therefore what will be considered in project selection are any uncertain events that will cause either negative or positive influence to the alternative’s performance on selected criteria (typically the project pay-off).

4.1.2 Risk analysis

Two types of analysis are usually carried out for analyzing risks in a project, namely the qualitative risk analysis and the quantitative risk analysis. Qualitative risk analysis aims to identify risks and obtain a general picture of their likelihood and impacts. Qualitative risk analysis often serves as a basis for quantitative risk analysis. Qualitative scales are structured to evaluate the likelihood and impact level of a certain risk. The outcomes often include a risk register and a risk probability-impact matrix.

50 Meredith and Mantel 2006
51 Project Management Institute 2000
52 Well-Stam, Lindenaar et al. 2004
For large-scale projects, quantitative risk analysis is required in addition to qualitative risk analysis. Probabilistic approach and simulation technique are typical methods for quantitative risk analysis.

For quantification purposes, risks can be classified into two categories, namely specific risk event (or event-driven risk) and standard uncertainties.\(^{53}\) The specific risk event can be defined with certain causes and consequences. If it happens, then the project will get influenced. The standard uncertainties refer to the uncertainties embedded in project cost and duration estimation. On the one hand, standard uncertainties occur as the result of the variation in unit prices, quantities and workable days, which are usually unavoidable. On the other hand, inaccuracy in cost and duration estimate also leads to uncertainties, which will get reduced as the project proceeds from planning, procurement to execution (see Figure 10).

Risks should be quantified in terms of both the probability of occurrence and consequences, and probabilistic distributions are used for modeling the quantification. Triangular distribution is proved to be effective and useful to model the consequences on cost and duration, where an optimistic, a most-likely, and a pessimistic value needs to be specified.\(^{54}\) The following figures show how specific event risks and standard uncertainties can be quantified proposed by the RISMAN approach:

\[\text{Figure 11 Quantifying specific event risk} \quad \text{Figure 12 Quantifying standard uncertainties}\]

In Figure 11 \(p\) stands for the probability of occurrence of a certain risk event. Accordingly, \(1 - p\) stands for the probability of non-occurrence of this risk event. When it happens, the consequence is quantified in triangular distribution, while when it does not happen, the consequence will be zero. Figure 12 shows the quantification of the standard uncertainty in triangular distribution.

When conducting quantitative risk analysis, software for carrying out simulation is needed and a base case together with the risks and uncertainties modeled in probability distributions is used as inputs. In order to reflect the real situation with more accuracy, usually correlations between risks and uncertainties also need to be modeled.

\(^{53}\) Well-Stam, Lindenaar et al. 2004  
\(^{54}\) Well-Stam, Lindenaar et al. 2004
4.2 Consider Risks in Project Selection

Risks and uncertainties can be taken as one of the criterion when making project selection. Some other qualitative or quantitative methods can be used to incorporate risks and uncertainties in project selection. In the following part the relevant theories will be presented.

4.2.1 Risk-adjusted methods

Risk-adjusted methods are usually used in financial/economic analysis.\(^5^5\) The basic idea is to adjust the inputs with consideration of risks. Usually the discount rate and cash flows can be adjusted to reflect the influences of risks.

- Risk-adjusted discount rate

The risk-adjusted discount rate is applicable for DCF-based methods and is for investors to use. Theoretically, the Capital Asset Pricing Model (CAPM) is often used for determining the risk-adjusted discount rate. The CAPM suggests the expected return should appropriately reflect the time value of money (risk-free rate) and a risk premium for the risks involved as indicated in the following equation:

\[
R_e = R_f + \beta(R_m - R_f), \quad \beta = \frac{Cov(R_e, R_f)}{Var(R_f)}
\]

Where:
- \(R_f\) - The risk-free interest rate
- \(R_m\) - The expected return of the market
- \(R_m - R_f\) - The market risk premium
- \(\beta\) - Beta, the measurement of the volatility of the expected return of a particular security or a portfolio compared to the expected return of the market as a whole

An alternative to the CAPM is the Arbitrage Pricing Theory (APT), which is also called the multifactor model. The APT holds that the expected return depends on all the risk factors, where sensitivity to changes in each factor is represented by a \(\beta\) separately.

\[
R_e = R_f + \beta_1(R_{factor1} - R_f) + \beta_2(R_{factor2} - R_f) + \cdots
\]

However, the methods proposed in theory are not easy to be applied directly in project evaluation in practice. It requires effort and usually not easy to determine the key parameters. In practice, Investors often estimate the risk premiums based on their own perceptions of the risk by rules of thumb.\(^5^6\)

- Risk-adjusted cash flows

Both in static methods and DCF-based methods, the inputs, such as the project cost estimate and cash flows can be adjusted with consideration of risks, which is an alternative to the risk-adjusted discount rate method. The probabilistic cost estimate approach plus risk analysis can produce the risk-adjusted cost estimate and cash flows. In DCF-based methods, the adjusted future cash flows

\(^5^5\) Götze, Northcott et al. 2008
\(^5^6\) Leeijen 2011
should be discounted by a risk-free discount rate in order to avoid double counting. In comparison with the risk-adjusted discount rate, this method is very straightforward and can be adopted by both contractors and investors.

4.2.2 Sensitivity analysis

Sensitivity analysis is widely applied in investment appraisal, which aims to investigate the relationships between the uncertainties involved in the various variables and the target values. Questions like how the target value can change when a certain variable or a combination of several variables change, and what value of a certain variable or a combination of variables should be achieved to ensure the target value to reach a required level can be addressed. When applying to the appraisal of a construction project, variables can be the initial investment, operation and maintenance expenditure, project economic life, project income, and/or discount rate, while the target value can be the project NPV or IRR.

By applying sensitivity analysis on the basis of DCF-based methods, major uncertain factors influencing the project return can be identified. The main pitfall lies in this method is there is no indication of the probability of the variable change.

4.2.3 Utility function and choices under uncertainty

The methods mentioned above try to evaluate the situation objectively. Although subjectivity cannot be eliminated from risk-adjusted methods, experts are usually consulted to establish more objective assumptions. When it comes to choices or decisions under uncertainty, the decision makers’ attitudes toward risk also matters and can be modeled in the form of utility function.

4.2.3.1 Concept of expected utility

Taking project evaluation and selection as an example, obviously the same evaluation result of project pay-off or other merits under uncertainty can mean differently to different decision maker. By introducing the concept of utility, how uncertain pay-off means to each decision maker can be explored.

Suppose the project profitability is the merit to be focused on, which can be measured by profit margin, NPV or IRR and is influenced by risks and uncertainties. After conducting financial/economic analysis with incorporation of quantitative risk analysis, multiple outcomes will be generated and each outcome would have a corresponding probability of occurrence. If to each possible pay-off of a certain project plan/bid a utility can be assigned to in an appropriate way, the expected utility of the project plan/bid can be calculated as the weighted sum of the utility assigned to each outcome and the corresponding probability of occurrence. The best choice to a decision maker is the one with the highest expected utility to him/her.

4.2.3.2 Structure utility functions

Structuring utility functions is a course of action to explore decision makers’ preferences and risk attitude. It suggests that utility functions could be structured by using the concept of certainty equivalent, which is the amount of pay-off that a decision maker would have to receive for sure in order to be indifferent between this pay-off and the uncertain case. Therefore utility functions can be

57 Götze, Northcott et al. 2008
58 Peterson 2009
structured through asking the decision maker to specify his/her preference towards uncertain outcomes and certainty cases iteratively. The following box shows an example of how a utility function can be structured. However it needs to be noticed that utility measures relative preference, which means decision makers’ utility functions could change as scale, time, and the object to be evaluated changes.

**Box 2 Example of how to structure a utility function**

Suppose the decision maker’s preferences are increasing in \( x \) and \( x_0 \) and \( x_1 \) are the two extremes and \( x_1 > x_0 \), we can set \( u(x_0) = 0 \) and \( u(x_1) = 1 \). Let’s consider the following two cases: 1) either \( x_0 \) or \( x_1 \) can be achieved, and 2) it is possible to achieve an \( x \) for sure. The decision maker will be asked to specify the \( x \) that makes him/her feel indifferent between the two cases.

According to the concept of expected utility, the following equation holds: \( 100\% \times u(x) = 50\% \times u(x_0) + 50\% \times u(x_1) = 50\% \times 0 + 50\% \times 1 = 0.5 \). By asking the decision maker to specify \( x \) making \( u(x) = 0.75 \), \( 0.25 \), and so on in the same way, the decision maker’s utility function of \( x \) can be structured.

**4.2.3.3 Risk attitude**

As can be seen from Box 2, utility functions are structured with consideration of the probability of occurrence of each possible outcome, which can therefore reflect the decision maker’s attitude towards risk. Typically, decision makers would possess risk aversion, risk seeking, or risk neutral, or a combination of the three risk attitudes.

**Box 3 Examples of different risk attitudes**

Let’s consider the following two cases: 1) receiving EUR 50 for sure, and 2) receiving either EUR 100 or 0. It can be easily understood that the expected consequences of both case equal to EUR 50.

A person is said to be risk-averse if he/she decides to accept a certain pay-off of less than EUR 50 rather than taking the uncertain case. In other words, his/her certainty equivalent is lower than the expected consequence of the uncertain case. On contrary, a person is risk-seeking if he/she would take the uncertain case unless receiving a sure payment more than EUR 50 and last but not least a person is risk-neutral if he/she is indifferent between the two cases.

The left picture in Figure 13 below illustrates the shape of utility functions that represent the different risk attitudes:

![Utility Function](image)

**Figure 13 Risk attitudes presenting in utility functions**

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59 Keeney and Raiffa 1976
A concave-shaped utility function shows a diminishing marginal utility, which reflect that uncertain cases with high pay-off will not be attractive to the decision maker in comparison to certain cases with lower pay-off, vice versa for the risk-seeking case. Some researchers have identified that in reality, decision makers will possess different risk attitudes toward loss and gain, which leads to the utility function depicted in the right picture in Figure 13.

### 4.2.4 Extension to project selection methods

The theory of expected utility and risk attitude can be incorporated in project selection methods to reflect the decision makers’ views to risk and uncertain pay-off. For instance, the results obtained by financial/economic analysis embedded with quantitative risk analysis can be linked to decision makers’ utility functions. In MCA, when risks and uncertainty needs to be considered, utility instead of value can be used to reflect decision makers’ preferences. For more theory on utility theory and its application please refer to Keeney and Raiffa’s, von Neumann’s, and Kahneman and Tversky’s works.

### 4.3 Risks in PPP Projects

#### 4.3.1 Sources of risks

According to the European PPP Expertise Center, transportation infrastructure PPP project risks can be divided into commercial risks and legal and political risks. Commercial risks include the supply and the demand side risks. The supply side risk refers to the construction risk, availability risk and financial risk, while the demand side risk refers to the traffic risk. Three major categories of risks that are typical for PPP projects are emphasized by the European Commission, namely the construction risk, the availability risk, and the demand risk as recorded in ESA 95.

At a macro-level, PPP project risks mainly include legal and political risks, and macro-economic risks. Examples of legal and political risks include unstable government, change in legal framework, regulations, and taxation. Due to the long-term operation period, PPP projects are exposed to macro-economic risks such as inflation and currency exchange rate fluctuation.

At a micro-level, construction risks, availability risks and financial risks are three major kinds of supply-side risks. Construction risks refer to the events or uncertainties that would have impacts on project objectives such as cost, schedule and quality, which is of no difference from non-PPP projects. Availability risks cover the operation phase of the project, which include all kinds of risks and uncertainties that would influence the availability and the quality of the facility. Financial risks refer to the risks associated with project financing or other financial type risks, e.g. changes in cost of capital like interest rate fluctuation. The demand-side risks mainly refer to the risk associated with the user demand, for instance, unanticipated change in traffic volume and vehicle types, etc.

#### 4.3.2 Typical risk allocation in Dutch DBFM projects

As mentioned in Chapter 1.1.1.1, one of the main characteristics of PPP is that the public and the private side are supposed to share risks; therefore risk allocation is one of the key elements in organizing PPP projects. According to the European Commission, the private side should bear the construction risk and at least one of either availability or demand risk in order to make the project benefit from “off balance sheet” treatment and thus not be accounted for when calculating public

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60 European PPP Expertise Centre 2010
Specific to the Dutch DBFM projects in the transportation infrastructure sector, typically the Project Company will be paid based on the availability payment, in other words, the private party will bear construction and availability risk, and the demand risk will be allocated to the public authority. Financial risks will also be allocated to the private side, but the public and the private side will share legal, political and macro-economic risks. In terms of inflation risk, usually the availability payment will be indexed to cover the risk. But the private party still bears the residual risk that the actual inflation is much higher than anticipated.

In terms of the risk allocation within the public-side actors, usually the construction and maintenance risks will be passed downwards from the Project Company to the EPC and O&M contractor as required for making the project bankable. In addition to the construction risks, the EPC contractor will also take the inflation risk on his part. The Project Company together with the O&M contractor will handle the availability risk. During the operation period, the O&M cost will also be indexed to cover the inflation risk. The Project Company will undertake the risk of default by EPC and O&M contractors. In terms of financial risk such as interest rate fluctuation, financial hedging in the form of interest rate swap is often used.

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61 Eurostat 2004
Section III Framework Development

In this section a two-part DBFM project evaluation framework established to assist construction companies’ project selection decision making in terms of DBFM projects is presented.
5 Framework Development

5.1 General Setup

The main objective of this thesis is to develop a project evaluation framework to assist the construction companies’ selection of DBFM projects. The three roles that construction companies play in DBFM projects need to be all considered, that is to say, the framework is required to be able to incorporate views of the decision makers representing different roles. Based on the theoretical framework established in the last section, the following framework is developed.

As can be seen from the figure above, the framework is divided into two parts. The first part deals with project screening during the early phase and can be applied before the pre-qualification. The second part attempts to provide a way to evaluate project risk and return during the later stage, e.g. during the dialogue and the final bid submission phase, to see if the project stays being attractive.

5.2 Part I – Project Screening

In the project screening part, the main goal is to prioritize the up-coming DBFM projects according to the company’s preference and decide which of the alternatives are more attractive to the company.
5.2.1 The approach

It was proposed in the previous chapters to apply the MCA approach because it can deal with both qualitative and quantitative information and incorporating multiple views. This part of framework will adopt the weighted sum-based method and follow the general approach of MCA. The expected output is to identify alternatives that are attractive to all the three roles.

![Framework implementation process](image)

Figure 15 Framework implementation process – Project screening

Figure 15 illustrates the process of the first part of the framework. In the initiation step, the decision problem needs to be specified and the decision makers should be identified. The second step aims to structure a set of criteria taking all three roles’ views into account. On the one hand, each individual decision maker’s preferences toward alternatives’ performances in terms of each criterion will be expressed in values, which will be further aggregated into group preferences by considering the decision makers’ priorities. On the other hand, decision makers also need to specify the importance they laid on each criterion by assigning weights, which will also be aggregated. The overall group preferences/scores will be calculated as the weighted sum of the aggregated criteria weights and the group preferences of alternatives’ performances on each criterion if independence condition is fulfilled.

5.2.2 The inputs

The inputs required for this part of framework include a set of criteria structured and weights assigned based on decision makers’ perspectives, evaluation of alternatives’ performances, decision makers’ preferences of alternatives’ performances, and decision makers’ priorities. It can be seen that among the inputs required, subjectivity plays a majority part; therefore it is important to ensure the process is
carried out in a way that the decision makers’ views and preferences are appropriately explored and reflected.

5.3 Part II – Individual Project Evaluation

The second part of the framework is established under the assumption that the company has decided to bid for a certain DBFM project and has started to develop the bid. The aim of the framework is to evaluate how the current plan/bid of a project will perform under risk and uncertainty and whether it can generate satisfactory return.

5.3.1 The approach

Financial/economic analysis will be adopted as the approach to evaluate the project return. Quantitative risk analysis is to be incorporated into the financial analysis using the risk-adjusted cost, revenue inputs, and cash flows to simulate the project return under uncertainty. The bid prices of the EPC, O&M bids and the availability payment are to be proposed based on the bidding and pricing strategies. With the formulated bid prices and the cost under the risk and uncertainty, it is possible to estimate the pay-off under uncertainty using simulation techniques, the results of which will be further linked to decision makers’ utility functions to find out what the uncertain pay-off means to different decision makers. Last but not least, sensitivity analysis can be carried out to identify the key influencing factors.

In order to measure the profit and specify the utility functions, it needs to be ensured that the profitability indicators chosen must be meaningful to the decision makers representing each role. For instance, to construction and maintenance contractor roles, profit margin estimated by static cost analysis can be used as measurement for potential profit, while to equity investor role, the IRR calculated using cash flows composed of equity invested and dividends received can be used. The application of utility theory can transfer profit measured in different ways into the same scale, the utility.

5.3.2 The inputs

The inputs required include cost estimate made based on the project design in question, project schedule, quantitative risk analysis, the planned bidding and pricing strategies, and decision makers’ utility functions of project pay-off. By linked to the project tasks and the schedule, cost estimated can be allocated to different time periods. The quantitative risks analysis includes both specific event risks as well as the standard uncertainty in cost and schedule estimates. The former should be linked to the influenced tasks while the latter should be linked to the corresponding cost and duration items. The inputs could be rough during the consultation and dialogue phase, but as the bid gradually developed, these inputs will become more detailed and more accurate. From the inputs needed we can see that the framework can evaluate different project plans taking the bidding and pricing strategies as given, or compare different bidding and pricing strategy for the same project plan.
Section IV Framework Practice

The framework developed in last section was applied to VolkerInfra to assist its selection of DBFM transport infrastructure projects. The screening part of framework was applied to the prioritizing among nine DBFM projects and the individual project evaluation part of framework was applied to the A15 MaVa case.
6 Decision Problem and Decision Group

In this chapter, the PPP project selection decision making is specified to the graduation company’s situation. First of all, the VolkerWessels group and its subsidiary companies that are relevant to DBFM transport infrastructure projects will be introduced. Then the definition and scope of the decision problem will be defined. Finally the composition of the decision group for the framework practice will be introduced.

6.1 Decision Problem Background

6.1.1 VolkerWessels

VolkerWessels (VW) group has been holding the position of the 2nd largest construction corporation group in the Netherlands for years. It has c. 125 operating companies and offices working in construction and related fields in the Netherlands, Belgium, Germany, the United Kingdom, Canada and the United States. The core target market of VW is the Netherlands with Canada being identified as a growth market.

The organization of VW can be subdivided into six major sectors, namely Construction and Property Development The Netherlands, Infrastructure The Netherlands, Energy, Infrastructure Technology and Telecoms, VolkerWessels United Kingdom, VolkerWessels Canada/United States, and Supplies and maritime. In the area of infrastructure, VW is active in civil engineering works, road construction, traffic management and engineering, and rail market. It reported 4,250 million euro in operating revenue over the year 2010. The property development (c. 30%), infrastructure (c. 30%) and infrastructure technology (c. 20%) sectors contribute to the majority of the revenue.

In terms of the overall development strategies, VW strives to enhance the operational excellence, that is to say, to carry out the activities better, smarter and at lower cost through improving project management, stimulating innovation and strengthening internal cooperation. A second strategy is to broaden VW’s position in the value chain both forward and backward by controlling raw material production and emphasizing service, management and maintenance respectively. In the long run, VW aims to achieve leading positions in the target markets in the Netherlands, the United Kingdom and Canada.

6.1.2 VolkerWessels and infrastructure DBFM projects

DBFM projects are attractive to VW not only because of the need to secure the market share and maintain a stable order backlog, but also because undertaking DBFM projects conforms to the development strategies in terms of enhancing the operational excellence and broadening the group’s position in the value chain. Currently VW is prepared to bid for more up-coming DBFM projects in the Netherlands and the company also has some interests in PPP/DBFM projects located in neighboring countries.

In the infrastructure sector, VW carried out the A8 Augsburg-München project in Germany as a member of the consortium together with Fluor, BAM, Egis and Berger Bau, which has reached construction completion successfully in 2010 and is considered as a successful reference project.

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62 VolkerWessels 2011
Within the Dutch market, VW also participated in the bidding of the A12 LuVe and A15 MaVa projects in 2010 but lost the two bids (ranked 3rd and 2nd respectively). VolkerWessels tries to learn from the setbacks and starts to realize that it might not sufficient to treat PPP projects in the same way as it treats D&C projects. The company is in need of a more integral approach that truly and effectively combines the three major elements involves in a PPP project, namely the construction, the maintenance and the project finance. In order to stimulate cooperation among subsidiary companies to meet the challenges brought by PPP projects, VW restructured internally, which includes legal and financial hires and setting up of an integral business unit VolkerInfra (see Figure 16).

![Figure 16 VW organization structure for infrastructure DBFM projects](image)

Below the integral business unit VolkerInfra and the four major VW operating companies relevant to DBFM transport infrastructure projects will be briefly introduced:

- **VolkerInfra**

  VolkerInfra is an internal partnership company among the other four VW operating companies. VolkerInfra plays the central role of ensuring an improved overall preparation and management of large-scale infrastructure projects, both D&C and PPP/DBFM projects, and seeks to achieve a unified approach in integrated design management, tender management, project management and support.

  VolkerInfra has three major disciplines, namely project management, public-private partnership, and asset management. Within the project management discipline, staffs offer integral support to project tender and management. VolkerInfra PPP focuses on PPP/DBFM projects and strives to coordinate internal expertise of the other four operating companies and attract external resources when it is necessary. It tries to add the SPV investor’s view and to come up with optimal bids for PPP/DBFM projects together with the other two VolkerInfra disciplines and colleagues from legal support and project finance departments. Asset management combines the individual strengths of the four operating companies in terms of maintenance to realize guaranteed availability through integral and innovative approaches for the client.

  In terms of development goals, VolkerInfra has the main objectives to pursue an integral approach for the tender and management of complex large-scale infrastructure projects, achieving reduction in failure costs, and stimulating the cooperation among the four VW operating companies.

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63 Source: [www.volkerinfra.nl](http://www.volkerinfra.nl)
• **Van Hattum en Blankevoort**

Van Hattum en Blankevoort (VHB) is one of the major operating companies of VW with the longest history. Up until now, VHB has been active in the Dutch infrastructure sector for about 180 years. VHB has the knowledge and capacity to realize almost all types of infrastructure works including civil infrastructure, marine works, foundations and offshore works. In the civil infrastructure discipline, VHB especially specializes in realizing complex steel and concrete structures such as tunnels, bridges, flyovers, aqueducts, sluices and storm surge barriers. VHB has involved in large-scale infrastructure projects such as the Afsluitdijk, the Zeeland Bridge, the Delta works, the Benelux tunnel, the Betuwe route and the High speed line.

Besides execution capacity, VHB also has its own design team (Volker InfraDesign) who conducts design work for civil infrastructures, road, and maritime structures, supports design management and system engineering through the whole design process from the preliminary to the final design, and therefore VHB is able to realize the execution of integral projects such as D&C and DBFM.

In addition to the target Dutch market, VHB has also executed projects world-wide. Volker Construction International (Volker CI) is the international arm of VHB, who has full excess to and shares the resources, knowledge, and technical expertise with VHB.

In terms of company vision and missions, VHB has the objectives to offer optimized solutions to the client with its own extensive technical and management expertise, and to deliver projects in the circumstance where safety, quality, and health are ensured and sustained. As for complex projects involving multiple disciplines, VHB together with other operating companies will work in an effective and innovative manner.

• **KWS Infra**

KWS Infra is one of the operating companies of the VW group who mainly focuses on the road construction work. The core business of KWS is consisted of the design, construction, reconstruction and maintenance of asphalt and concrete pavements (e.g. roads, paths, yards and airports), drainage and earthworks. The scales of projects that KWS undertakes vary from repairing sidewalks to complex integral projects.

KWS not only carries out the specified works, but also pays attention to achieve innovations in energy consumption, noise pollution and soil contamination control. In addition, KWS has its own asphalt plant in several cities in the Netherlands and it produces about 20% of all the asphalt in the country, which enhances the KWS’s competence through increasing efficiency.

• **VolkerRail**

As one of the dynamic and innovative operating companies of the VW group, VolkerRail specializes in the railway infrastructure-related field. It has the expertise and capacity to carry out the construction of train, light rail, tram and metro tracks as well as the maintenance of existing

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64 Source: [www.vhbinfra.nl](http://www.vhbinfra.nl)
65 Source: [www.kws.nl](http://www.kws.nl)
66 Source: [www.volkerrail.nl](http://www.volkerrail.nl)
rail infrastructure and installations. The business scope of VolkerRail extends beyond rail tracks to the asset management of tunnels, bridges and locks.

In terms of mission and vision of the company, VolkerRail aims to hold the leading position in the field, and provide the client with innovative solutions to realize accessibility, availability and acceleration through improved processes, at reduced costs, and with a sustainable manner. In addition to the local Dutch market, VolkerRail also has offices in the UK, Germany and several other European countries.

- **Vialis**

  Vialis focuses on traffic and railway technology and its main task is to realize a traffic network of high accessibility, safety, and quality. In terms of future goals, Vialis starts to shift emphasis from merely delivering technical products to providing life-cycle services with the primary objective of ensuring the guaranteed availability.

  The main products and services provided by Vialis include traffic control and information systems, motorway signs, street lighting, railway signaling, parking direction systems, and e-payment systems for public transportation. The business scope of Vialis also includes the installation and maintenance of the traffic systems mentioned above.

  Although most Vialis projects take place in the Netherlands, the company is international-oriented, especially in the research and development aspect. Subsidiary companies in Belgium, Poland and Asia are all contribute their expertise to the field of mobility and traffic safety.

### 6.2 Decision Problem Definition and Scope

In short, the decision in question deals with whether VW should or should not bid a certain infrastructure PPP project. Since VW has a very decentralized organization structure, it is usual the case that VolkerInfra, the VW operating companies together with VW financial and legal departments prepare and submit project bid proposals to the VW management board. Here the decision scope will focus on this lower level, where the different roles’ perspectives need to be considered and combined in an appropriate way.

The decision problem can be sub-divided into two parts, namely a project screening part, and an individual project evaluation part. Among the up-coming PPP projects in the target home and foreign markets, which of them are of attractiveness to the company and therefore should be selected forms the first part of the decision problem. After the project screening, long-term project bidding processes shall start. For each individual project, to track whether it is still of interest to the company and decide whether or not to continue to be a player forms the second part of the decision problem.

67 Source: [www.vialis.nl](http://www.vialis.nl)
### 6.3 Decision Group Formulation

The table below shows the formulation of the decision group for the attempt to apply the framework. Mainly the project-level decision makers are involved.

**Table 4 Decision group formulation**

<table>
<thead>
<tr>
<th>Role</th>
<th>Representative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction contractor role</strong></td>
<td></td>
</tr>
<tr>
<td>VolkerInfra (general)</td>
<td>ir. M.S. Bakker (Director VolkerInfra, VolkerInfra)</td>
</tr>
<tr>
<td>VHB/KWS (road &amp; civil)</td>
<td>Ing. R.J Brouwer (Director of Projects, VHB)</td>
</tr>
<tr>
<td>VolkerRail (rail)</td>
<td>ir. E.P. Stoelinga MBA (Senior Manager PPP, VolkerInfra)</td>
</tr>
<tr>
<td><strong>Maintenance contractor role</strong></td>
<td></td>
</tr>
<tr>
<td>VolkerInfra (general)</td>
<td>ir. M.S. Bakker (Director VolkerInfra, VolkerInfra)</td>
</tr>
<tr>
<td>VolkerInfra Asset Management</td>
<td>Ing. R.F.A. de Ridder (Director Asset Management, VolkerInfra)</td>
</tr>
<tr>
<td><strong>Investor role</strong></td>
<td></td>
</tr>
<tr>
<td>VW Treasury &amp; Finance</td>
<td>Mrs. A. den Otter (Director Treasury &amp; Finance, VolkerWessels)</td>
</tr>
<tr>
<td>VW Project finance</td>
<td>Ms. C.M.C.M. Appels (Project Finance Manager, VolkerWessels)</td>
</tr>
<tr>
<td>VolkerInfra PPP (SPC-level equity investment)</td>
<td>Ir. A.H. Naafs (Director VolkerInfra PPP, VolkerInfra)</td>
</tr>
</tbody>
</table>
7 Part I – Project Screening

The following nine DBFM projects are considered as alternatives, to which the project selection framework will be applied:

- N33 Assen – Zuidbroek
- A15 Verbreiden Maasvlakte – Vaamlein (A15 MaVa)
- A12 Utrecht – Maarsbergen – Veenendaal (A12 LuVe)
- SAA – A1/A6 Diemen – Almere Havendreef
- SAA – A9 Gaasperdammerweg
- SAA – A9 Amstelveen Badhoevedorp – Holendrecht
- SAA – A6 Almere Havendreef – Almere BO
- North-South route in Limburg (Belgium)
- Groningen RegioTram

It is assumed that all these 9 projects are to be tendered during more or less the same period; therefore a situation that the company needs to make selection among them can be structured. Among the 9 alternatives, some of the projects are up-coming projects, while others are past projects on which the company has already made decisions. For instance, the A12 LuVe and A15 MaVa projects have already achieved financial close in 2010, and the company has decided not to bid the Groningen RegioTram project. These past projects are included as alternatives for validation purposes and will be treated as if they are up-coming new projects. Each alternative will be briefly introduced below. Introduction of the alternatives can be found in Appendix III.

In this chapter, first of all, the selected criteria and measurements will be presented and discussed, which are the results of the first-round interviews. Furthermore, criteria weights and decision makers’ priorities will be assigned. Last but not least, individual evaluation results will be presented and aggregated into group results.

7.1 Criteria and measurement

7.1.1 Structuring the criteria set

A first-round of interviews was carried out to structure a suitable set of criteria for the selection of DBFM projects. All the decision makers were asked to take specific consideration of his/her role in DBFM projects. Some project selection criteria identified from the literature were used as a reference (refer to Appendix II). The figure below presents the set of criteria established based on the results of the first-round interviews.

Explanation:

- Project-related criteria
  Project-related criteria include “Project size”, “Project conformity to business scope”, “Project complexity” and “Project location”. “Project size” is subdivided into “Shareholder funding amount”, “Construction size” and “Maintenance size”, which reflects the three roles’ views explicitly. “Project size” gives indication of the projects that are favorable to the company in terms of sizes, which is determined by the company’s development strategies and restrained by the available resources.
“Project conformity to business scope” reflects the company’s preferences toward project types and scopes, which is also determined by the company’s development strategies and would probably be influenced by previous experiences. It can also reflect the project risk profile and potential profit implicitly in that usually the company is more confident in controlling and managing risks of the projects that are fully in line with the business scope and there would be a higher probability to achieve satisfactory profit.

“Project complexity” includes complexity in management, technical and financial aspects. Here management complexity refers to the complexity involves in the internal and external relationships of the project, which will increase as the number of stakeholders involved in the project increases. It is also possible to have a situation that only a limited number of stakeholders involved but they possess very strong resistance toward the project, which will also increase the management complexity. Technical complexity refers to complexity involves in the technical aspects to deliver the work, which will increase as the number of technical disciplines and interfaces involved in the project increases. The use of new technology will also increase the project technical complexity. Financial complexity refers to the complexity involves in the project financing. A large number of banks are needed or other institutional lenders are available or allowed means there will be more complicated debt terms and guarantees, which will increase the financial complexity. “Project complexity” also reflects the project risk profile and profit potentials implicitly. Higher complexity means not only higher level of risk but also greater potential to gain higher return.

“Project location” refers to the countries and/or areas that projects are located in. Usually a company would have several target geographical markets in accordance with the development strategies.

- Client-related criteria
Client-related criteria include “Client type” and “Client experience with PPP procurement”, which reflect who the client is and its capability to organize PPP/DBFM projects.

- **Procurement-related criteria**
  Bidding cost refers to the cost that would incur during the bidding process, which usually includes external financial, legal and technical advisory hires and internal design and tender management staff cost. Majority of the bidding cost can be considered as fixed cost, and therefore it would be more attractive for the company to bid projects of larger size than that of smaller sizes due to the more or less the same amount of bidding cost.

- **Competition-related criteria**
  “Number of competitors” and “Competitors’ competencies” together reflects the degree of competition, which further provides information for the company in terms of the probability of winning the bid. Competitors’ competencies can be reflected in their turnovers and previous experience with PPP projects.

**Criteria quality assessment:**

It requires that the criteria should be comprehensive, measurable, operational and complete with no overlaps or redundancies. The following paragraphs will assess the quality of the structured set of criteria in terms of these four requirements.

- **Comprehensive: criteria and company’s business strategies**
  A criterion is comprehensive means the decision maker will be able to know clearly about the extent the associated objective is achieved by knowing the level of an attribute in a particular situation. In terms of comprehensiveness, the project- and client-related criteria can reflect the business strategies of VW. That is to say, decision makers are able to know clearly about the extent the associated objectives are achieved by knowing the level of certain criteria in a particular situation. For instance, VW strives to maintain the leading position in the market through increasing market share and maintaining relationship with target clients, which is reflected in the “project size”, “project location” and “client type” criteria. Another business strategy that VW adopts is to achieve operational excellence by increasing the overall profit and minimizing project risks. The probability of achieving higher profit and better risk control involves in the criteria “project conformity to business scope” and “project complexity”. Decision makers can also get a clearer picture of the degree of competition from the competition-related criteria, which directly influence the anticipation of probability of winning.

- **Measurable: consideration of risk and profit**
  By measurable it means that it is possible to assess consequence of each alternative in terms of each criterion, and it should also be possible to obtain preferences of the decision maker toward the consequences in the form of value function, rank ordering and so on. During the interviews, all the decision makers agreed that project potential profit and risk profile were two important factors that need to be considered. However they also mentioned the difficulty to carry out cost, financial and risk analysis for measurement of these two factors quantitatively during the early stage. Therefore finally “scope conformity” and “project complexity” were used because these

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68 Keeney and Raiffa 1976
two criteria can somehow grasp the decision makers’ intuition about project risk profile and potential profit.

- Complete with no overlaps or redundancies: other mentioned elements
  It is crucial to structure a set of criteria/attribute that is sufficient to reflect all the important aspects that the decision maker wants to emphasize. However, double-counting needs to be avoid. During the interviews, decision makers also mentioned some other factors that would influence their decisions such as the need for work, previous experience with similar projects, partners’ technical and financial capabilities, and the availability of required resources. For the consideration of completeness with no overlaps or redundancies, these factors were left out of the criteria set. Some of them are overlapped with the existing criteria. For instance, if the company is in special need for a certain kind of project, it will be reflected in their preference of project scope and will be further connected to the “scope conformity” criterion. If the company has extensive successful previous experience with a certain kind of projects, it will be reflected in their judgment of the project complexity. Some of these factors should not be considered as project selection criteria. For example, the “availability of required resources” factor is more of a constraint since the framework is designed to choose the most attractive project(s) in order to allocate resources efficiently. Moreover, finding a partner is more of an option that can be taken to make the project become more attractive instead of a given condition, and therefore partner-related factors should also not to be considered as project selection criteria.

- Operational
  Criteria should be operational means they should be easily understandable to decision makers. The structured set of criteria was presented to the interviewees for their confirmation. All the interviewees agreed that there was no difficulty in understanding the meanings of each criterion. Although there were some different perceptions existed for certain criteria, finally decision makers all accepted the explanation of each criterion given above and so everybody was attuned to the same page.

7.1.2 Criteria measurement

During the first-round interviews, the ways of measurement of criteria were also discussed.

- Project size

  Table 5 Measurement – project size

  | Shareholder funding amount | The equity amount can be estimated as 10% of the estimated total funding cost. The total funding cost can be estimated as 120% of the construction size. | In EUR million |
  | Construction size | If construction cost has been roughly estimated, it should be used as measurement of the construction size; otherwise the indicative CAPEX mentioned by the government could be used. | In EUR million |
  | Maintenance size | If the maintenance cost has been roughly estimated, it could be used as measurement of the maintenance size; otherwise the maintenance size can be roughly estimated as 12 to 14% of the total project size. | In EUR million |

- Project conformity to business scope

  Project scope conformity can be somehow reflected in project size, but it could also be the situation that the part of project that is outside the company’s business scope does not have much
share in the project size, and what matters more are the potential risks that the company cannot control. Therefore qualitative scale with verbal description is used to measure this criterion.

Table 6 Measurement scale – scope conformity

<table>
<thead>
<tr>
<th>Scale</th>
<th>Verbal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully conforms</td>
<td>The project scope is fully in line with the companies' business scope.</td>
</tr>
<tr>
<td>Mostly conforms</td>
<td>Majority of the project scope is in line with the companies' business scope, plus minor scope outside and the companies cannot control or are not protected from it.</td>
</tr>
<tr>
<td>Partially conforms</td>
<td>Partial of the project scope is in line with the companies' business scope, plus partial scope outside and the companies cannot control or are not protected from it.</td>
</tr>
<tr>
<td>Limitedly conforms</td>
<td>Minor of the project scope is in line with the companies' business scope, plus majority scope outside and the companies cannot control or are not protected from it.</td>
</tr>
</tbody>
</table>

- Project complexity

It is difficult to structure quantitative measurement scales for project complexity, therefore some verbal descriptions are given to help obtaining relatively objective measurement.

- Management complexity

Table 7 Measurement scale – management complexity

<table>
<thead>
<tr>
<th>Scale</th>
<th>Verbal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>Extensively many stakeholders involved, very strong resistance exists, extensively many internal management disciplines involved</td>
</tr>
<tr>
<td>High</td>
<td>Many stakeholders involved, strong resistance exists, or many internal management disciplines involved</td>
</tr>
<tr>
<td>Moderate</td>
<td>A moderate number of stakeholders involved, resistance exists, or a moderate number of internal management disciplines involved</td>
</tr>
<tr>
<td>Low</td>
<td>A small number of stakeholders involved, no obvious resistance exists, or a small number of internal management disciplines involved</td>
</tr>
<tr>
<td>Very low</td>
<td>A limited number of stakeholders involved, no resistance exists, or a limited number of internal management disciplines involved</td>
</tr>
</tbody>
</table>

- Technical complexity

Table 8 Measurement scale – technical complexity

<table>
<thead>
<tr>
<th>Scale</th>
<th>Verbal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>Extensively many technical interfaces involved, extensively many technical disciplines involved, or brand new technology required</td>
</tr>
<tr>
<td>High</td>
<td>Many technical interfaces involved, or many disciplines involved</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate number of technical interfaces involved, or moderate number of technical disciplines involved</td>
</tr>
<tr>
<td>Low</td>
<td>A small number of technical interfaces involved, or a small number of technical disciplines involved</td>
</tr>
<tr>
<td>Very low</td>
<td>A limited number of technical interfaces involved, a limited number of technical disciplines involved, or of a routine work character</td>
</tr>
</tbody>
</table>
- Financial complexity

<table>
<thead>
<tr>
<th>Scale</th>
<th>Verbal description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>A large number of banks needed, or very diversified financial sources are available, e.g. pension funds, insurance companies also involved</td>
</tr>
<tr>
<td>Moderate</td>
<td>A moderate number of banks needed</td>
</tr>
<tr>
<td>Low</td>
<td>A small number of banks needed</td>
</tr>
</tbody>
</table>

- Project location

This criterion is to be measured simply by the geographical location of the alternative. According to the introduction of the VW group and its development strategies, the project locations that will be attractive to VW as a whole include: the Netherlands, the UK, and Canada. To VolkerInfra and the four VW subsidiary companies, upcoming DBFM projects in the project list are mainly located in the Netherlands and Belgium.

- Client type

Client type is to be measured simply by the type of the public authority who procures the projects. Usually clients include the Dutch State and the local governments and public authorities abroad.

- Client experience with PPP procurement

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive</td>
<td>Previously organized more than 3 PPP projects</td>
</tr>
<tr>
<td>Limited experience</td>
<td>Previously organized less than 3 PPP projects</td>
</tr>
<tr>
<td>No experience</td>
<td>First-timer</td>
</tr>
</tbody>
</table>

- Bidding cost

Since to some extent, the majority of the bidding cost is fixed. It is often the case that when the project size falls in a certain range, it would cost more or less the same amount to bid. As the project size increases sharply, the bidding cost amount will not increase proportionately but at a much lower rate. Therefore it is considered to be more reasonable to measure it as a percentage of the total project size.

- Number of competitors

This criterion is to be measured simply by counting the number of potential competitors.

- Competitors’ competencies

A construction company’s competence can be reflected in its turnover and previous experience with PPP projects. However it is hard to develop objective measurement scale, and usually there will be more than one competitor, therefore the overall competitors’ competencies will be evaluated more subjectively with consideration of the two elements mentioned above.
7.2 Value functions

7.2.1 Structuring value functions

After structuring the criteria set and deciding the measurement, a second-round of interviews was organized. During the interviews, for each criterion, the decision maker’s preferences were explored and presented in the form of a value function. All the value functions were structured from value 0 to 1, where 0 stands for the worst case and 1 represents the best case.

The direct rating method was the approach applied to structure the value functions for the criteria with qualitative scales. Decision makers were asked to give values to different scales for each criterion directly. For instance, Table 12 below shows the value functions of sub-criterion construction scope conformity structured by all the decision makers. Although the decision makers were required to value the worst case as 0, but to some certain criteria, some decision makers felt even the worst case in the scales would not be extremely unfavorable to be sufficient for a value 0. Since one of the major requirements of structuring value functions is to reflect decision makers’ preferences appropriately, in some value functions the worst cases that included in the scales were not always be valued as 0.

Table 12 Value functions – Project conformity to business scope – construction scope

<table>
<thead>
<tr>
<th>Scale</th>
<th>Value</th>
<th>VHB/KWS</th>
<th>VolkerRail</th>
<th>VolkerInfra (general)</th>
<th>VW Finance &amp; Treasury</th>
<th>VW Project Finance</th>
<th>VolkerInfra PPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully conforms</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Mostly conforms</td>
<td>0.75</td>
<td>0.80</td>
<td>0.80</td>
<td>0.50</td>
<td>0.25</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Partially conforms</td>
<td>0.50</td>
<td>0.40</td>
<td>0.50</td>
<td>0.20</td>
<td>0.10</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Limitedly conforms</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

For the criteria of which the consequences are continuous, the bisection (i.e. the mid-value point technique) method is also used as assistance. Taking project size as an example, first the decision maker was asked to specify the project size that is too small and is absolutely not attractive to the company, and then specify the project size that is too big for the company to handle alone. After specifying the two extremes, the decision maker was asked to also specify the project size that he/she would give a value of 0.5, 0.25 and 0.75. The figure below shows the value function of construction size specified by the decision maker who represents VHB/KWS.
An exception is the value function of the bidding cost. All decision makers agreed that generally speaking the lower the bidding cost will be preferred. Therefore the ideal (but unlikely) 0% was valued as 1, and among the alternatives, the bidding cost never exceeds 2% of the total funding amount, which is taken as the other extreme, i.e. value of 0.

7.2.2 Discussion

- Some findings from the structured value functions
  From the value functions structured, some role-specific preference tendency can be concluded, which mainly showed in value functions of project size and complexity. In terms of construction size, the value functions generally show the same pattern, where projects of very small sizes are not attractive, and then the value will increase quickly as the project size increase. When the project size becomes very large, the value will decrease, which is mainly due to the reason that construction companies are subject to capacity constraints. However, since the decision makers always consider finding partners when encountering projects of very large sizes, which is usually possible, the value will not decrease sharply but much more slowly. An exception applies to the rail part of construction size, where VolkerRail is one of the biggest players in the Dutch rail market and in this sector it will be unlikely the situation that a rail/light rail project coming to the market would exceed the company’s capacity to build and/or maintain.

Different from construction size, value functions of maintenance size show decision makers prefer larger-size projects. The main reasons for it are on the one hand, maintenance sizes are not likely to vary dramatically as construction size, and on the other hand, it is easier and more flexible to re-allocate resources for maintenance projects.
In terms of the shareholder funding amount, generally speaking, decision makers are in favor of smaller amount of equity, which reflects that the company commit equity investment as a strategy to secure the EPC and O&M part of work.

In terms of project complexity, decision makers representing different roles showed quite different preferences. Generally speaking decision makers who represent the construction and maintenance contractor role prefer higher technical complexity but lower management complexity, while decision makers representing the investor role are in favor of lower project complexity.

- Preference independence check
  One requirement for aggregating the overall value function in the form of the weighted sum of single-criterion value functions is that the mutual preferential independence needs to be met. That is to say, the decision maker’s preference order of the alternative performances on one criterion should not be influenced by the alternative performances on other criteria. The box below gives an example of preferential independence.

**Box 4 Example of preferential independence**

Let us consider two criteria, “project location” and “project size”. Suppose there are two projects X and Y, both are of EUR 500 million in size, but X is located in the Netherlands while Y is located in Germany. The decision maker prefers X to Y. Now suppose that the sizes of both projects are changed into EUR 300 million, the decision maker still prefers X to Y. If the decision maker’s preference towards the consequences on “project location” remains the same if we change the sizes of both projects to any other value, we can say that in this case “project location” is preferential independent of “project size”.

During the interviews, majority interviewees were able to structure the value function of each criterion independently without consideration of other criteria, which justifies the existence of mutual preferential independence. Still, independence check was carried out to detect any dependencies may exist. Each time two criteria were considered. Decision makers were asked to confirm whether their preference order of alternative performances on one criterion would change when the alternative performs differently in terms of other criteria. Some decision makers confirmed that their value function of one criterion would not change no matter how the alternative performs differently on other criteria, while some decision makers indicated that to some extent, their value functions would hold.

However, “Project size” was found to be not preferentially independent of “Project scope conformity”. For instance, the decision makers who represent the construction and maintenance contractor roles indicated that when the project scope mostly or partially conforms to the company’s business scope, they would prefer a project of larger size, while one decision maker who represents the investor role indicated that he would prefer smaller amount of equity in this case. Decision makers were asked to structured value functions of “Project size” with consideration of the level of “Project scope conformity” to see how their preference would change exactly. The results show although the values would change slightly, in majority of the cases, in the project size range that the considered alternatives fall in, the preference orders still hold.

Completely mutual preferential independence cannot always be reached in reality, and it is believed that even when there is no complete independence, the weighed sum value model can
still provide a close approximation of the decision maker’s preference.\textsuperscript{69} Although “Project size” is related to “Project scope conformity”, they each capture different and important aspects of a project and cannot be simply left out or combined. It is also very difficult to structure value functions when more than one criterion need to be considered simultaneously. Therefore in this framework, the weighted sum is still used to aggregate the overall value as an approximation of the decision makers’ preferences.

Besides, some criteria are found to be preferentially dependent on some other elements that are not included in the criteria set. For instance, one of the decision makers indicated that when it takes a short time to generate the preferred bidder, larger number of competitors will not be a big problem, but when the process takes more than six months, numerous competitors will be much less favorable.

### 7.3 Criteria Weights

Besides structuring the set of criteria and the value functions, another important step is to assign weights to each criterion to express its importance from the perspective of the decision maker. Here the widely-used pair-wise comparison method was applied to assist the decision makers to derive weights of the criteria. The eigenvalue/characteristic value approach was adopted as the solution to work out the weights from the pair-wise comparisons.

As showed in Figure 17, the criteria were structured in the form of a hierarchy. The decision makers were first asked to make pair-wise comparisons of the four criteria categories in terms of their importance to the goal, prioritizing DBFM projects. A 1 to 9 scale proposed by Saaty was used to express the relative importance of one criteria category to the other (see Table 13). The comparisons will result in a pair-wise comparison matrix and Table 14 shows an example. By calculating the eigenvector of the matrix using the Saaty approach, relative weights of the four criteria categories can be obtained. Since when making comparisons, at each time the decision maker only considers the two categories in question. It can lead to problem of inconsistent comparison results. Therefore the consistency was checked to ensure the pair-wise comparisons that the decision maker made are consistent.

### Table 13 Relative importance scale

<table>
<thead>
<tr>
<th>Intensity of importance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
</tr>
<tr>
<td>3</td>
<td>Moderate importance of one factor over another</td>
</tr>
<tr>
<td>5</td>
<td>Strong or essential importance</td>
</tr>
<tr>
<td>7</td>
<td>Very strong importance</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance</td>
</tr>
<tr>
<td>2, 4, 6, 8</td>
<td>Intermediate values</td>
</tr>
<tr>
<td>Reciprocals</td>
<td>Values for inverse comparison</td>
</tr>
</tbody>
</table>

\textsuperscript{69} Yoon and Hwang 1995
After comparing the categories, under each category, the first level of criteria was pair-wise compared against their importance toward the category. The process repeated until all levels of criteria were compared. During the whole process, attention was paid to ensure all the decision makers understood and measure the criteria in the same way. It needs to be noticed that the high precision level of the weights were resulted simply from the calculation.

Table 15 shows an example weights matrix in the view of the decision maker representing VolkerInfra PPP. The weights in black indicate the relative weights of the sub-criteria/criteria with respect to their main criterion/category, while the weights in blue indicate the relative weights of the categories, criteria or sub-criteria with respect to the goal, prioritizing DBFM projects. It needs to be noticed that the high precision level of the weights were resulted simply from the calculation.

As can be seen from Figure 17, decision makers representing different roles will have view on some of the criteria but not all of them. For instance, in terms of project complexity, decision makers representing the construction and maintenance contractor roles only care about management and technical complexity. When this is the case, the relative weight of financial complexity was assumed to be zero and the proportion of the other two sub-criteria weights was held the same.
In addition to the criteria weights derived per individual, criteria weights were also aggregated into criteria weights per role and overall criteria weights. A preferred and recommended way to derive group weights is to organize group discussion and seek consensus. However, it is inapplicable during the process due to time limit and difficulty in organizing meetings among all the interviewees. The Saaty’s approach for aggregating weights derived by pair-wise comparisons was adopted as an alternative, where the geometric mean is used to aggregate individual judgments.

For each criterion, after checking the consistency, all individual pair-wise comparison matrices were aggregated into one matrix, where the aggregated result for each pair-wise comparison is the geometric mean of all individual results. And then using the same way of deriving individual criteria weights, criteria weights per role and overall criteria weights can be obtained. It needs to be noticed that when aggregating criteria weights of a role, only the comparison matrices made by the decision makers who represent this role were taken into account.

Table 16 presents the weights (global) assigned to each criterion (level 2) by different decision makers, as well as the aggregated weights per role and the overall aggregated weights. From the table the following observations can be concluded:

- Most of the decision makers placed the highest weights to “scope conformity” except decision makers representing VHB/KWS and VolkerInfra Asset Management, who thought “bidding cost” was the most important criterion.
- Except the decision maker representing VolkerRail, all decision makers gave project complexity middle to high weights. The possible reason could be VolkerRail is one of the biggest player in the Dutch rail infrastructure market, which makes the decision maker become less sensitive to the project complexity since the company is confident in dealing with it.
- From the aggregated weights per role and the overall weights, it can be seen that “scope conformity”, “project complexity”, “bidding cost”, and “client type” could be decisive factors in comparison with the rest.

For detailed explanation of the weighting approach used above, please refer to Saaty 1980 and Triantaphyllou 2000. A questionnaire was designed to assist the decision makers to make pair-wise comparisons (see Appendix V).

7.4 Decision Makers’ Priorities

In DBFM project selection, different roles will have different priorities, while different decision makers representing the same role would have different priorities, too. In the formulated decision group, there is no decision maker who is superior to all the other decision makers and is able to assign weights to each decision maker. Therefore similar to the way deriving the criteria weights, decision makers’ priorities were derived by interpersonal pair-wise comparisons made by each decision maker under the assumption that all the decision makers have the same priority in terms of assigning weights.

In terms of each criterion, a hierarchy can also be established for the decision makers (see Figure 20). First of all, the roles involved were compared, and then within each role, the decision makers were compared. All the decision makers were asked to consider the positions/functions they have in the organization so as to avoid awkward interpersonal confrontation. The decision makers’ priorities were aggregated into priorities per role and overall priorities.
Table 17 below presents the results of decision makers’ priorities, from which the following observations can be concluded:

- Within the construction contractor role, the decision maker representing VHB/KWS has higher priority in terms of majority of the criteria, followed by the decision maker representing VolkerRail, which could be explained by that majority of the up-coming DBFM projects are road and civil infrastructure projects and that will be the focus of the company. The decision maker representing VolkerInfra (general) has the lowest priorities. A reason for this outcome could be VHB/KWS and VolkerRail are those who will actually undertake the projects while VolkerInfra (general) provides management support.

- Within the maintenance contractor role, in terms of project-related criteria, the decision maker representing VolkerInfra Asset Management has higher priorities than the decision maker representing VolkerInfra (general), and vice versa for the rest of the criteria.

- Within the equity investor role, the decision maker representing VW Finance & Treasury has extremely high priority. The decision maker representing VolkerInfra PPP has much higher priorities for the rest of the criteria.

- In terms of role priorities, for those criteria that two or three roles have views to, it can be seen that the construction contractor role has the highest priority, followed closely by the maintenance contractor role. The equity investor role possesses lower priority except for the client-related criteria and “bidding cost”.

Figure 20 Decision makers hierarchy
Table 16 Criteria weights – global weights

<table>
<thead>
<tr>
<th>Criteria (level 2)</th>
<th>Individual</th>
<th>Weights</th>
<th>Role</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VHB/KWS</td>
<td>VolkerRail</td>
<td>VI</td>
<td>VI AM</td>
</tr>
<tr>
<td>Project size</td>
<td>0.0138</td>
<td>0.0606</td>
<td>0.0737</td>
<td>0.0373</td>
</tr>
<tr>
<td>Scope conformity</td>
<td>0.1249</td>
<td>0.4243</td>
<td>0.4337</td>
<td>0.0226</td>
</tr>
<tr>
<td>Project complexity</td>
<td>0.1392</td>
<td>0.0308</td>
<td>0.1727</td>
<td>0.0612</td>
</tr>
<tr>
<td>Project location</td>
<td>0.0289</td>
<td>0.1153</td>
<td>0.0525</td>
<td>0.0075</td>
</tr>
<tr>
<td>Client type</td>
<td>0.0117</td>
<td>0.0794</td>
<td>0.1453</td>
<td>0.0801</td>
</tr>
<tr>
<td>Client experience with PPP procurement</td>
<td>0.0817</td>
<td>0.0113</td>
<td>0.0311</td>
<td>0.2092</td>
</tr>
<tr>
<td>Bidding cost</td>
<td>0.5428</td>
<td>0.0343</td>
<td>0.1120</td>
<td>0.4025</td>
</tr>
<tr>
<td>Number of competitors</td>
<td>0.0142</td>
<td>0.2000</td>
<td>0.0103</td>
<td>0.0421</td>
</tr>
<tr>
<td>Competitors’ competencies</td>
<td>0.0427</td>
<td>0.0400</td>
<td>0.0308</td>
<td>0.0084</td>
</tr>
</tbody>
</table>

Table 17 DMs’ priorities

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Priorities</th>
<th>DMs priorities within each role</th>
<th>Role priorities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VHB/KWS</td>
<td>VolkerRail</td>
<td>VI</td>
</tr>
<tr>
<td>Project size</td>
<td>0.5543</td>
<td>0.2900</td>
<td>0.1557</td>
</tr>
<tr>
<td>Maintenance size</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Equity amount</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scope conformity</td>
<td>0.5776</td>
<td>0.2802</td>
<td>0.1421</td>
</tr>
<tr>
<td>Maintenance scope</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Management complexity</td>
<td>0.4827</td>
<td>0.3501</td>
<td>0.1672</td>
</tr>
<tr>
<td>Construction part</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Technical complexity</td>
<td>0.4848</td>
<td>0.3972</td>
<td>0.1180</td>
</tr>
<tr>
<td>Financial complexity</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Project location</td>
<td>0.4864</td>
<td>0.3373</td>
<td>0.1763</td>
</tr>
<tr>
<td>Client type</td>
<td>0.3964</td>
<td>0.3964</td>
<td>0.2072</td>
</tr>
<tr>
<td>Client experience with PPP procurement</td>
<td>0.4015</td>
<td>0.3718</td>
<td>0.2267</td>
</tr>
<tr>
<td>Bidding cost</td>
<td>0.4838</td>
<td>0.3840</td>
<td>0.1322</td>
</tr>
<tr>
<td>Number of competitors</td>
<td>0.4512</td>
<td>0.3129</td>
<td>0.2359</td>
</tr>
<tr>
<td>Competitors’ competencies</td>
<td>0.4751</td>
<td>0.3361</td>
<td>0.1888</td>
</tr>
</tbody>
</table>
7.5 The Model

The decision model for project screening is established in Microsoft Excel 2007 with Visual Basic Application (VBA) programming. The model is composed of two parts, namely front stage sheets and the backstage sheets. The front stage sheets include an alternative information input sheet and a result sheet. The information needed for evaluation is to be inputted through a questionnaire.

The backstage sheets store the value functions, the criteria weights and the decision makers’ priorities. When new decision makers are involved, the currently involved decision makers change their preferences, or the currently-used criteria set requires modification, these sheets need to be updated.

Once the alternative information is inputted, the model automatically assigns the correspondent values to the alternative in terms of each criterion based on the stored value functions from the view of each decision maker, and finally generates the score summary for the alternative based on the generated values and the stored weights. This process is realized through Excel functions and the application of VBA macros. For the model setup, please refer to Appendix V.

7.6 Results

7.6.1 Scores and ranks

Based on the measurement scales developed in Chapter 7.1.2, each alternative can be evaluated in terms of their performances on each criterion (see Table 18). For the criteria that could involve subjectivity such as project complexity and competitors’ competencies, it would be better to ask experts or colleagues who are more familiar or experienced with these certain aspects. In this application, the evaluation was made by the author based on information obtained from the interviews. The information presented was used as input to the decision model.

Taking the A15 MaVa project as an example and input all the evaluation results into the model, a value/score matrix can be obtained in the view of each decision maker (see Table 19), so as the values/scores given per role and the overall score. The scores and ranks of all the alternatives derived by the model are presented in Table 20, from which the following observations can be concluded:

- It can be seen that the A15 MaVa project hold a position in the top 2 steadily in both individual and aggregated results. So as the N33 and Groningen RegioTram projects who possess the relatively lower positions among the alternatives.

- For other alternatives, the ranks vary as per role. From the results per role it can be seen that alternatives preferred by contractors are likely to be less preferred by investors. Reasons to explain this include that on the one hand decision makers representing the contractor roles are in favor of high project complexity while decision makers representing the investor role are not, and on the other hand, the project size that decision makers representing the contractor roles feel satisfied would result in a large amount of equity capital, which is also not preferred by decision makers representing the investor role.

- When aggregating into the overall score/rank, the construction and maintenance contractor roles’ priorities are much higher than the investor role, which leads to an overall rank closer to the rank generated by these two roles. The overall ranks indicate that to the formulated decision group, among these 9 alternatives, the A15 MaVa and SAA A1/A6 were ranked the highest, followed by
the other three SAA projects. The Groningen RegioTram, the N33, and the A12 LuVe projects were ranked low.

7.6.2 Detailed analysis and the possibility for improvement

It is also possible to compare the alternatives in terms of their scores obtained on each criterion in more detail, which can provide further insight of the alternatives. Figure 21 below shows the comparison of the top 2 and bottom 2 alternatives based on the overall ranks. It can be seen that the two highly-ranked alternatives perform more or less the same in terms of each criterion. However the two bottom-ranked alternatives show different performances, in other words, they were scored low for different reasons.

The N33 project performs less favorable because of the relatively small project size, very low project complexity and the competition situation with numerous competitors of more or less the same competencies, which are all aspects that the company cannot influence. The only possible way to increase the attractiveness of this project is to lower the bidding cost. On the one hand, when there are no better alternatives exist and the company needs to grow its order backlog, a small-size and rather simple project like N33 can be a choice. On the other hand, when there are better alternatives exist, it could be wise for VW to step back from the competition for a small and simple project like this and save resources for other better opportunities.

On contrary, the Groningen RegioTram project performs less favorable in terms of very high project complexity and partially conformed scope, which can be improved by finding appropriate partners. For instance, by finding an experienced tram operator as partner can reduce the project complexity to the favorable level and mitigate the possible risks borne in the part of scope that outside VW’s business scope. Besides, by finding appropriate partners, it is possible to share the equity amount needs to be invested and the bidding cost, which can make the project become attractive to the company. If VW can find appropriate and trustworthy partners, this project can become much more favorable.
From the above analysis we can see that based on the results generated by the framework, the company should:

- Consider bidding projects having higher ranks, e.g. the A15 MaVa and the SAA A1/A6 project;
- Consider bidding projects having lower ranks but can be improved, e.g. the Groningen RegioTram project;
- When the company needs to grow its order backlog and there are no better opportunities, consider bidding projects having lower ranks due to lack of challenge, e.g. the N33 and the A12 LuVe projects;
- Consider not bidding projects having lower ranks due to large sizes, very high complexity and scope inconformity and yet cannot be improved.
### Table 18 Performance matrix – Alternatives summary

#### General information:

<table>
<thead>
<tr>
<th>Project name</th>
<th>N33 Assen - Zuidbroek</th>
<th>A15 MaVa</th>
<th>A12 LuVe</th>
<th>SAA A1/A6</th>
<th>SAA A9 Gasperramweg</th>
<th>SAA A9 Amstelveen Badhoevedorp - Holendrecht</th>
<th>SAA A6</th>
<th>The north-south route</th>
<th>Groningen RegioTram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project type</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road</td>
<td>Civil, road, light rail</td>
</tr>
<tr>
<td>Construction duration (approx.)</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>6.5</td>
<td>5.5</td>
<td>3.5</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Operation duration</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>22.5</td>
</tr>
</tbody>
</table>

#### Information specific to criteria:

<table>
<thead>
<tr>
<th>Project size (in EUR million)</th>
<th>Construction size</th>
<th>Maintenance size</th>
<th>Equity amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction size</td>
<td>140</td>
<td>900</td>
<td>15</td>
</tr>
<tr>
<td>Maintenance size</td>
<td>40</td>
<td>150</td>
<td>110</td>
</tr>
<tr>
<td>Equity amount</td>
<td>30</td>
<td>210</td>
<td>160</td>
</tr>
</tbody>
</table>

#### Scope conformity:

<table>
<thead>
<tr>
<th>Construction scope</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Fully conforms</th>
<th>Partially conforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance scope</td>
<td>Fully conforms</td>
<td>Fully conforms</td>
<td>Fully conforms</td>
<td>Fully conforms</td>
<td>Fully conforms</td>
<td>Fully conforms</td>
<td>Fully conforms</td>
<td>Partially conforms</td>
<td></td>
</tr>
</tbody>
</table>

#### Project complexity:

<table>
<thead>
<tr>
<th>Management complexity</th>
<th>Construction part</th>
<th>Maintenance part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Very low</td>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Very low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Very low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical complexity</th>
<th>Construction part</th>
<th>Maintenance part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Very low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Very low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financial complexity</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>Moderate</th>
<th>Moderate</th>
<th>Low</th>
</tr>
</thead>
</table>

#### Project location:

<table>
<thead>
<tr>
<th>North NL</th>
<th>Central NL</th>
<th>Central NL</th>
<th>Central NL</th>
<th>Central NL</th>
<th>Central NL</th>
<th>Belgium (near the Dutch border)</th>
<th>North NL</th>
</tr>
</thead>
</table>

#### Client type:

| RWS | RWS | RWS | RWS | RWS | RWS | RWS | Municipality Groningen |

#### Client experience with PPP procurement:

| Extensive | Extensive | Extensive | Extensive | Extensive | Extensive | Limited | No |

#### Bidding cost (in EUR million):

| 3 | 5 | 5 | 7.5 | 7.5 | 7.5 | 5 | 2 | 5 |

#### Number of competitors:

| 8 | 3 | 3 | 5 | 5 | 5 | 4 | 3 |

#### Competitors’ competencies:

| Moderate | Moderate | Moderate | High | High | High | High | Moderate |

### Table 19 Value/score matrix – A15 MaVa

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Individual</th>
<th>Values/Scores</th>
<th>Role</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VHB/KWS</td>
<td>VI</td>
<td>VI AM</td>
<td>VI PPP</td>
</tr>
<tr>
<td>Project size</td>
<td>0.92</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maintenance size</td>
<td>-</td>
<td>1.00</td>
<td>1.00</td>
<td>-</td>
</tr>
<tr>
<td>Equity amount</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.00</td>
</tr>
<tr>
<td>Scope</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Table 20 Scores and ranks

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Score/rank</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Individual</td>
<td>Role</td>
</tr>
<tr>
<td></td>
<td>VHB/KWS</td>
<td>VI</td>
</tr>
<tr>
<td>N33 Assen - Zuidbroek</td>
<td>0.33</td>
<td>9</td>
</tr>
<tr>
<td>A15 MaVa</td>
<td>0.88</td>
<td>1</td>
</tr>
<tr>
<td>A12 LuVe</td>
<td>0.47</td>
<td>8</td>
</tr>
<tr>
<td>SAA - A3/A6</td>
<td>0.85</td>
<td>2</td>
</tr>
<tr>
<td>SAA A9 Gaasperdammerweg</td>
<td>0.79</td>
<td>3</td>
</tr>
<tr>
<td>SAA A9 Amstelveen Badhoevedorp - Holendrecht</td>
<td>0.79</td>
<td>3</td>
</tr>
<tr>
<td>SAA A6</td>
<td>0.69</td>
<td>6</td>
</tr>
<tr>
<td>The north-south route</td>
<td>0.77</td>
<td>5</td>
</tr>
<tr>
<td>Groningen RegioTram&quot;&quot;</td>
<td>0.49</td>
<td>7</td>
</tr>
</tbody>
</table>

For this project, the view of the decision maker representing VolkerRail was included.
8 Part II – Individual Project Evaluation

The second part of framework was applied to the A15 MaVa project. In this Chapter, first of all, a brief introduction of the project will be made, including project description, the consortium, the payment mechanism and the risk allocation. Then the framework will be applied and the structured utility functions, the spreadsheet model, and the results will be described and discussed. It needs to be noticed that here the framework application is a hypothetical exercise carried out on a real project with a lot of simplifications. The final bids of all the consortia were submitted in 2010 and the project has been awarded.

8.1 Project Introduction

8.1.1 General information

The A15 MaVa project involves the improvement of a 37-km section of the A15 from Maasvlakte to the Vaanplein interchange and construction or refurbishment of 40 structures, and it is an availability payment-based DBFM project. To be more specific, the project is divided in 3 main sections:

- Western Section (Suurhoffbridge - Hartelkruis) is light reconstruction of 8 km;
- Botlek Corridor (Hartelkuis - Aveling) is heavy reconstruction and building new vertical lift bridge including bridge technical installations;
- Eastern Section (Aveling - Ridderster) is heavy reconstruction.

Along these three sections, the project will also consist of:

- Construction, refurbishment and demolishing of a various amount of viaducts;
- Construction of two junctions (Beneluxplein and Vaanplein);
- Optimizing two existing tunnels (Thomassen tunnel and Botlek tunnel) including tunnel technical installations;
- Building a total new dynamic traffic management system over 37 km; and
- Control of noise and air pollution.

Sources: http://mava-industryday.nl/, http://www.rijkwaterstaat.nl
The construction and maintenance sizes of the project are estimated to be about EUR 900 million and EUR 150 million (i.e. EUR 7.3 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 110 million.

There are numerous stakeholders involved in the project. Major ones include Port of Rotterdam, City of Rotterdam, Safety and Fire Department Rijnmond and several other local authorities. This increases the complexity in the project relationship to the external parties. Other factors making the project complex include the construction of the Botlek Bridge, and the bridge and tunnel installations.

8.1.2 The consortium

For the A15 MaVa project, VolkerWessels partnered with Heijmans and Fluor and formed a bidding consortium called OptimA15. Each of them is assumed to commit equity capital investment and to participate in the EPC and O&M contracting. DIF (Dutch Infrastructure Fund) is also a consortium member who provides capital and project finance expertise.

8.1.3 Payment mechanism

In the A15 MaVa project, the consortium will be paid by the public authority based on the availability of the facility. The payment mechanism of this project is of a typical Dutch DBFM project style: partial availability payment during construction period for the maintenance of existing and to be built infrastructure, plus two lump sum payments and full availability payment during the operation phase.

Figure 23 Payment profile

Figure 23 above illustrates the payment that the consortium will receive. During the construction period, two availability dates will be scheduled as proposed by the consortiums during the procurement process, which will determine the time for the consortium to receive the two milestone payments. Before the interim availability date, the consortium will receive 20% of the Gross Availability Payment (GAP), which will increase to 40% after the interim availability date. After getting the availability certificate on the availability date, the public authority will start to pay the 100% amount of GAP to the consortium. Since the risk of inflation is shared between the public and the private parties, the GAP during the operation phase will be indexed.

All the bids submitted by the consortia that made it to the final tender stage were compared in terms of the NPV calculated by discounting the GAP and lump sum payments with the discount rate specified in the tender instruction. A ceiling price applies here, which is about EUR 838,000,000 at the price level of Jan. 1, 2008. Besides pricing, the submitted bids were also compared in terms of considered quality aspects-related criteria, which were not considered in this framework application.

8.1.4 Risk allocation

- Risk allocation between the public and the private sides
As mentioned earlier in Chapter 4.3.2, in Dutch DBFM projects, usually the private party is assumed to accept the construction risk and availability risk, and no demand-side risk will be imposed to the private sector. This also applies here in this project. In addition to the risks belong to these two broad categories that are clearly lies in the private-side responsibility scope, during the procurement process, several risks that lies in the grey area were discussed in terms of their allocation. Risks such as presence of unexpected soil pollution, cables and pipelines, timeliness of granting permits, deviation of geotechnical conditions and change in law were referred to as Listed Risks and the consortiums can choose to absorb all or some of these risks, or allocate them to the public authority as compensation events. These risks can also be shared by both parties. If the consortium chooses to accept the Listed Risks, the above-mentioned ceiling price will be adjusted higher accordingly and vice versa in the situation where Listed Risks are ascribed as compensation events. The consortium chose to accept all the listed risks, which resulted in a higher ceiling price of about EUR 900 million.

- Risk allocation within OptimA15
  All the key risks associated to the design, construction and routine maintenance are passed downwards from the SPC to the construction and maintenance contractors by the back-to-back EPC and O&M contracts. The revenue risks, i.e. the risk events that have consequences on the availability payment, are assumed to be shared by the SPC, EPC and O&M contractors. The SPC undertakes its operation risk and the risks related to heavy maintenance.

<table>
<thead>
<tr>
<th>Risk category</th>
<th>SPC</th>
<th>EPC</th>
<th>O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and construction risk</td>
<td></td>
<td>x</td>
<td></td>
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<tr>
<td>Maintenance risk</td>
<td></td>
<td></td>
<td>x</td>
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<tr>
<td>Heavy maintenance risk</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPC operation risk</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Revenue risk</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

8.2 Utility Function

8.2.1 Structuring utility functions

During the 2nd-round interviews, utility functions were structured through interaction with interviewees. The method suggested in Box 2 was applied. The utility functions ranges from -1 to 1 in order to express the decision maker’s attitude toward gain and loss more explicitly. All the decision makers were asked to consider the A15 MaVa case instead of a more general attitude.

Here below are the utility functions of all the decision makers within the decision group formulated in the project screening phase who are relevant to this project:
8.2.2 Reflection

From the utility functions presented above, it can be seen that most of the decision makers can be considered as being risk averse for the gain and risk-seeking for the loss. In the gain situation (i.e. utility from 0 to 1), most of the decision makers prefer a certainty case of lower pay-off than the uncertain case of higher pay-off, which makes their utility functions present the concave shape, vice versa for the loss situation. An exception is the decision maker representing VolkerInfra (general), who shows risk-seeking attitude in terms of EPC and O&M profit margins. It can also be seen from the utility functions that decision makers’ attitude toward risk can possibly not always held the same, where risk neutral, risk averse and risk-seeking can alternately occur.
It needs to be pointed out that the two extremes of each utility function were specified by decision makers instead of obtained from the simulation results because simulation results were not available at that time. This could be a limitation as it mentioned in Chapter 4.2.3.2 that the relative utility modeled in utility functions can be influenced by changes in scales.

8.3 The Model

A spreadsheet model was established in Excel to show how the project can be evaluated when risks and uncertainties can be considered in a quantitative manner and how they can be related to project return. The contractual relationship and risk allocation are structured in the model and different project return indicators are used to measure return specific to a certain role, namely, the EPC profit margin for the construction contractor role, the O&M profit margin for the maintenance contractor role, and equity IRR for the investor role, which are selected because the company is familiar with these measurements. In reality, it is possible for different partners within the consortium to ask for different profit margins. Here it is assumed that all partners will be at equal positions and the project will be evaluated as a whole with no further distinctions among different partners.

Uncertainties and risks were modeled into the base case and simulations were carried out to estimate the project return under uncertainties and risks, which is realized by using Crystal ball. The structured utility functions were programmed in the model in the form of user-defined formulas. After obtaining the simulation results, for each single result, an accordant utility can be obtained. And the expected utility is the weighted sum of each utility and its probability of occurrence. For a more detailed explanation of the model setup, please refer to Appendix VI.

8.4 Results

8.4.1 The EPC part

First of all the EPC cost was simulated under the risk and uncertainty assumptions. Due to lack of information about unit price and quantity, the standard uncertainty in cost and duration only took the inaccuracy of estimation into account. The minimum value was estimated as 95% of the base case while the maximum value was modeled as 110% of the base case. Such assumption is based on Figure 10. The difference between the P80 simulation result and the base case was the contingency amount, which leads to an EPC bid price of about EUR 937 million. Simulation was carried out again and the forecast of EPC profit margin is showed in the figure below:
It can be seen that the EPC profit margin of the current bid under uncertainty ranges from about -2% to 12%. The VolkerWessels group as a whole has the objective to achieve an EBITDA margin of around 5% during the year before 2012.\textsuperscript{72} From the results we can see that the probability of achieving an EPC profit margin higher than 5% is about 55%. With respect to the utility function of the decision maker representing VHB/KWS, the expect utility of the current bid amounts to 0.59. In other words, the uncertain pay-off that can be obtained from the bid is equivalent to a certain case of receiving 5.04% of profit margin. As for the decision maker who represents VolkerInfra (general), the results are 0.50 and 5.00% respectively. The results show that the current project plan/bid can generate adequate return for the construction contractor role.

8.4.2 The O&M part

The same approach was adopted to simulate the O&M profit margin and the following results were obtained:

\textsuperscript{72} VolkerWessels 2011
It can be seen that the O&M profit margin of the current bid under uncertainty ranges from about -6% to 10% and the probability of achieving an O&M profit margin higher than 5% is about 9.5%. In terms of the expect utility and certainty equivalent, the results for VolkerInfra (general) are -0.48 and 1.54% respectively, and the results for VolkerInfra Asset Management are -0.27 and 1.73% respectively. The utilities below zero show that the current project plan/bid cannot provide the maintenance contractor role with adequate return.

### 8.4.3 The equity part

The EPC and O&M bids are taken as inputs to the financial model to calculate the equity IRR. In this way, the investment part of return will not be subject to risks that are allocated to the EPC and O&M part, which reflects the risk allocation. It is assumed that the ceiling price will be the amount of income that the Project Company would receive from the public authority. Figure 29 shows the simulation results.

It can be seen that the equity IRR of the current bid under uncertainty ranges from about 9% to 13%. The target equity IRR that the bidding consortium expected is 12%. From the results we can see that the probability of achieving an equity IRR higher than 12% is about 1.28%. To the decision maker representing VolkerInfra PPP, the expected utility of the equity IRR is 0.39 and the certainty equivalent is 10.78%. While to the two decision makers represents VW Finance & Treasury and VW Project finance, the results are 0.19 and 10.75%, and 0.38 and 10.76% respectively. The results show...
that the current project plan/bid can hardly generate the required target return and is of positive but low utility to the decision makers representing the equity investor role.

Figure 29 Simulation results – Equity IRR

8.4.4 Sensitivity analysis
Sensitivity analysis was carried out to identify the key influencing factors of the three profit components, which is realized by Excel and Crystal ball. For the EPC and O&M profit margins, the variables included the cost items, risks, profit markup and contingency, i.e. all the assumptions, which deviated from -10% to 10% from the base case one at a time. Variables were ranked by the percentage deviations of the profit margins from the base case caused by the percentage change in each variable.

Figure 30 and Figure 31 show the sensitivity analysis results of the EPC and O&M profit margins respectively, where the top-10 variables that the profit margins were sensitive to are presented. The results show that the EPC and O&M profit margins are positively correlated with profit markup and contingency amount, while negatively correlated with cost items. It can also be concluded from the results that to achieve higher profit margin, reducing the cost would be more effective than increasing the bid price for the same amount. For the EPC part, attention needs to be paid to control the construction cost of the Botlek corridor and Trace Oost parts, while for the O&M part, attention needs to be paid to control the cost of corrective maintenance for mechanical and electrical installations, routine maintenance, pavement maintenance, etc.
The sensitivity analysis results of the equity IRR show that it is very sensitive to the EPC bid price and the debt percentage. If other variables are held the same, higher EPC bid price would lead to lower equity IRR, while higher debt percentage would lead to higher equity IRR.
In terms of the current bid, since it is assumed that the company presents a bid with price equal to the ceiling price, it is not possible to increase the overall bid price. It is possible to achieve a higher O&M profit margin by reducing the cost or adding higher profit markup or contingency, in other words, proposing a higher bid price for the O&M part. Obviously the latter would cause inferior influence to the equity return since the overall bid price cannot be increased in this case. From Figure 32 we can see that equity IRR is slightly sensitive to the O&M bid price, but how the slight change in equity IRR when increasing the O&M bid price means to the decision makers representing the equity investor role depends on their utility functions.

To obtain a higher equity IRR, reducing the EPC bid price would be the most effective way, however it would probably lead to severe decrease in the EPC profit margin and increase risk on the EPC part. Similarly, the decision makers’ preferences and attitudes determine how this decrease matters to them.

If the bid is developed in the way that the overall bid price is lower than the ceiling price, then it is possible to increase the overall bid price to obtain adequate profit for each role without influencing each other. However this solution would reduce the chance of winning the tender.

It is possible to also carry out simulations to further explore how each of and a combination of these possible solutions could optimize the bid. Due to time constraints, no further studies on these possible solutions were carried out. Therefore how to reach an optimal distribution of profit and meanwhile formulate a competitive bid needs further consideration.

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73 In the base case the debt percentage is 90%, therefore when it is increased by 10%, there will be no equity investment and there should be no equity return. In the sensitivity analysis this extreme deviation was set at 99%. When the debt percentage is more than 99%, the equity IRR will increase sharply.
Section V Conclusions and Recommendations

In this section conclusions that can be drawn from the research are presented, followed by some practical recommendations on the application of the framework and suggestions to future work.
9 Conclusions and Recommendations

9.1 Conclusions

The research objective stated in this thesis is:

To develop a project evaluation framework that supports construction companies in their PPP project selection decision making process integrating the perspectives of the equity investor and the construction and maintenance contractors involved.

In order to achieve this objective, three research questions are formulated:

- What project selection methods do currently exist and which of these are appropriate and applicable for PPP project selection decision making within the contractor industry?
- During this decision making process, how can risks and uncertainties be considered and how can these be quantitatively justified?
- How can the interests of different decision making parties involved be incorporated into the framework taking into account the specific focus during each phase of the bidding process?

Relevant literature was studied and interviews were carried out to explore what probable solutions to these research questions exist. This was used as the basis for developing the DBFM project evaluation framework. Then the framework was applied to the graduation company to support its DBFM project selection decision making process. Below are the conclusions that can be drawn from this study.

9.1.1 Conclusions on project selection methods

Financial/economic analysis, multi-criteria analysis and portfolio selection are identified as three main categories of project evaluation methods that can be used to assist project selection.

After making comparisons of the various methods mentioned above, specific to DBFM projects selection and evaluation, it was proposed in the thesis to use MCA during the early phase, e.g. before the pre-qualification phase, while to use financial/economic analysis during the dialogue and the final bid submission phases.

From the framework application, the following conclusions can be drawn:

1. MCA can be an applicable approach for the DBFM project selection before the pre-qualification phase because it creates a rational basis for decision makers to compare and prioritize alternative projects by consider all the important aspects in a systematic way.

2. Financial/economic analysis can give straightforward evaluation of project pay-off and is applicable during the dialogue and the final bid submission phases when quantitative information is available.

9.1.2 Conclusions on consideration of risks and uncertainties in project selection

Risks are often considered in a qualitative way during the early stage due to lack of information, which can be used as basis for quantitative analysis in the later stage when it is possible. Risk-
adjusted methods, sensitivity analysis and the application of utility theory are identified as possible ways to take risks and uncertainties into account quantitatively when making project selection.

With respect to the proposition of using MCA and financial/economic analysis in early and later phase respectively, it was proposed in the thesis that in MCA, risks and uncertainties can be considered qualitatively by being taken as one of the criteria and measured by conducting qualitative risk analysis. In financial/economic analysis, sensitivity analysis can be conducted to identify the major risks or uncertainties that can influence the project pay-off in a qualitative way, while for quantitative consideration of risks and uncertainties, risk-adjusted methods can be applied where the inputs such as the cash flows or cost estimates can be adjusted to incorporate risks. Last but not least, when risk quantification is feasible, utility theory can be applied to both financial/economic analysis and MCA to incorporate the decision makers’ risk attitudes.

From the framework application, the following conclusions can be drawn:

1. In the early phase risk quantification is almost impossible and it is even difficult to carry out qualitative risk analysis. When applying MCA in the early phase, consideration of risks can somehow be reflected in some other criteria (e.g. in the framework practice part I, consideration of risks is reflected in the “scope conformity” and “project complexity”). As the bid gets developed gradually, risks and uncertainties can be quantified by using probabilistic approach and risk-adjusted cost/cash flow method can be applied in financial/economic analysis to link the risks to the project pay-off straightforwardly. Simulation techniques make it feasible.

2. Structuring utility functions can integrate decision makers’ risk attitudes and the evaluation results of project return. It makes decision makers’ interpretations of uncertain project pay-off become clearer.

3. Conducting sensitivity analysis can identify the key influencing factors and therefore can provide more insight to the problem.

9.1.3 Conclusions on incorporation of multiple interests in project selection

Answer to the 3rd research question was generated along with answering the first two research questions and the application of the framework. It can be concluded that when applying MCA, it is possible to form a decision group and take each decision maker’s view and preferences into account. A set of criteria that concludes all aspects that the decision group focuses on can be structured. Through appropriate aggregation, individual preferences can be aggregated into group preference. The application of utility theory in financial/economic analysis can link the objectively measured profitability indicators to the decision makers’ risk attitudes and therefore reflect different views.

9.1.4 Deliverables

A two-part conceptual framework was developed based on the answers to the research questions. The first part of the framework, the project screening part, follows the general approach of MCA. The main goal is to prioritize up-coming DBFM projects according to the company’s preference and decide which of the alternatives are more attractive to the company. It is proposed to form a decision group where decision makers representing different roles need to be included and to structure a set of criteria covering all the aspects that all the decision makers concern about. Decision makers’ perspectives are to be reflected in the weights they assign to the criteria and their preferences towards
alternatives’ performances on each criterion. Different perspectives will be aggregated into a group view by considering the priorities of the decision makers.

The second part of the framework is established under the assumption that the company has decided to bid for a certain DBFM project and has started to develop the bid. The aim of the framework is to evaluate how the current plan will perform under risk and uncertainty and whether it can generate satisfactory return. Financial analysis will be adopted as the approach to evaluate the project return. Quantitative risk analysis is to be incorporated into the financial analysis using the risk-adjusted cost, revenue inputs, and cash flows to simulate the project return under uncertainty, which will be further linked to decision makers’ utility functions to find out what the uncertain pay-off means to different decision makers.

Figure 33 Deliverable – DBFM project evaluation framework
9.2 Recommendations

Some practical recommendations in terms of DBFM project selection and the application of the framework will be given below, followed by some recommendations on future work.

9.2.1 Practical recommendations

General recommendations

1. It is recommended to consider all the three roles’ perspectives when making DBFM project evaluation, which can help to get an overall picture of the project and provide more information for the decision making.

2. It is recommended to apply the conceptual framework developed in this thesis in practice and further improve it. It needs to be noticed that the framework can only provide information to assist decision making and cannot replace decision makers. In the framework practice made in this study, only a limited number of project-level decision makers were involved in the decision group. It would also be interesting to see what results will be generated if the views of the board-level and statutory management-level decision makers are incorporated.

3. The framework developed in this thesis tries to support decision making by integrating evaluation results with decision makers’ preferences and risk attitudes, which can be influenced by their previous and typical experience. The framework treats this information implicitly in alternative scoring and the utility function structuring. Therefore it is recommended to pay attention to the possible bias caused by previous experience and try to learn from the past in a rational way.

Recommendations on the framework practice part I – project screening:

1. The project screening part of the framework deals with DBFM project selection in an early stage, e.g. before the pre-qualification phase. The MCA approach provides a way to find out which of the alternatives are of interest to the company. It is recommended to apply it in practice, and continuously improve and update it.

2. In the framework application carried out in the thesis, the set of criteria was derived from the results of individual interviews. It is recommended to organize group discussions among the decision makers to seek group consensus in terms of criteria selection. It is necessary to make sure that the criteria selected are comprehensive, operational, measurable and complete with no overlaps and redundancies.

3. The criteria weights were assigned using questionnaires and aggregated into group weights using the geometric mean method in the framework application illustrated in this thesis. It is important to make sure every decision maker understands and measures the criteria in the same way when assigning criteria weights. It would be more efficient to organize group discussion to arrive at consensus. The group weights aggregated using the geometric mean method can be used as a basis for discussion.

4. It can be seen that criteria weights, decision makers’ priorities and their preferences will influence the final outcome. Sensitivity analysis on these inputs is recommended to be carried out to gain more insight to the problem.

5. The results generated by this part of the framework are rankings of the alternatives derived from their performances on the criteria and the decision makers’ preferences. It needs to be noticed that
the framework can only provide information to assist decision making and cannot replace decision makers. The following are the suggestions on how to utilize the results:

- Consider bidding projects having higher ranks;
- Consider bidding projects having lower ranks but improvement is possible;
- When the company needs to grow its order backlog and there is no other better opportunities at hand, consider bidding projects having lower ranks due to lack of challenge;
- Consider not bidding projects having lower ranks because they are too challenging and yet mitigation is not possible.

**Recommendations on the framework practice part II – individual project evaluation:**

1. The individual project evaluation part of the framework focuses on evaluating project risks and pay-off. The application of utility function makes it possible to reflect decision makers’ attitudes toward risk in an explicit way. It is recommended to apply this part of the framework during the dialogue and the final bid submission phases to decide whether or not to continue the current bid. This part of framework can also be used to compare different project plans or variants adopting the same bidding and pricing strategy, or the different bidding and pricing strategies used for the same project plan.

2. Risk quantification is required in the framework, which would probably need much effort and resources. It is still recommended to apply it because risk and uncertainty cannot be ignored in DBFM projects and the benefit could outweigh the possible cost. In terms of consideration of risks and uncertainties, it is recommended to not only consider the risks themselves separately but also their interactions and correlations with each other in an integral way. Besides, in order to get a more realistic evaluation, risk allocation stipulated in the DBFM agreement and EPC and O&M contracts should also be considered.

3. Simulation techniques make it possible to link quantitative risk analysis to project pay-off. The quality of the inputs needs to be ensured in order to avoid “garbage in, garbage out” problem and to generate credible results. It would be necessary to consult experts in terms of estimate of cost, risk probability and consequences. It is also recommended to establish a project database documenting information such as estimates and actual performance during execution and implementation.

4. It is recommended to structure utility functions to approximate decision makers’ risk attitude, i.e. preferences toward uncertain pay-off, which can transfer the objectively-evaluated profitability indicators to something meaningful to and can be understood by all the decision makers. However it needs to be noticed that utility measures relative preference, which means decision makers’ utility functions could change as scale, time, and the object to be evaluated changes.

5. The results generated by this part of the framework are probability distributions of project pay-off measured in profit margin, or IRR, etc, and the expected utility and certainty equivalent that reflect decision makers’ satisfaction of the uncertain project pay-off. Again, it needs to be noticed that the framework can only provide information to assist decision making. The utility functions cannot model decision makers’ preferences and risk attitudes in complete accuracy and decision makers will not always behave rationally.

The following are the suggestions on how to utilize the results:
- If the current plan/bid can generate high utility to all three roles, consider adopt it and seek further optimization;
- If the current plan/bid can generate high utility to one or two roles but low utility to the others, consider discussion and negotiation to see if trade-off can be made to arrive more preferable outcome;
- If the current plan/bid generates low utility to all three roles, the project plan, the bidding and pricing strategy need to be re-examined to seek improvement.

9.2.2 Recommendations on future work
1. The starting point of the framework application was to explore what is attractive or preferable to the company, i.e. it is internally-oriented. However, some external constraints or influence factors can also affect the company’s decisions and cannot be ignored. For instance, a DBFM project of an estimated size that is ideal for the company could become unfavorable if it exceeds the ceiling price set by the government. How to better consider the external constraints and influence factors requires some further consideration.

2. In this thesis, the weighted sum-based MCA method using value functions for scoring, and pairwise comparisons for weighting was applied in the application of the first part of the framework. It would be interesting to also use other different MCA methods to see which of them can reflect decision makers’ preference more appropriately and what outcomes would be.

3. The second part of the framework was applied to one case as an illustration of how it works. It would be interesting to compare different plans of a project and incorporate the flexibility involved. In addition, to construction companies, to some extent the return that can be earned depends on the bidding and pricing strategies. In this thesis, these elements were taken as inputs and it is shown in the application that the framework can somehow contribute to bid optimization, which could be an interesting topic for further research.

4. It was also found in the application of the framework that previous experience of success or failure can influence the decision makers’ preferences and risk attitudes, which were implicitly reflected in the framework. In reality, previous experiences could have decisive influence to project selection, therefore to learn from the past rationally and critically is necessary. Research on past PPP projects could provide lessons learned and contribute to project selection.

5. The value functions and utility functions structured in the framework are all attempts to capture persons’ preferences and risk attitudes, which require higher analytical skills. And in the framework, the application of utility theory ends with structuring individual utility functions. Research on how to structure utility functions that can properly reflect decision makers’ preferences and attitudes, and how to possibly aggregate individual utility functions to model group preference and attitude in a proper way could be interesting to do.

6. The thesis focused on the Dutch DBFM projects in the transport infrastructure sector. The framework developed was applied to a Dutch construction corporation group and typical Dutch DBFM transport infrastructure projects. It would be interesting to see how the approaches proposed can be generalized to other PPP models applied in other sectors and countries.
### List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AHP</td>
<td>Analytic Hierarchy Process</td>
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<tr>
<td>APT</td>
<td>Arbitrage Pricing Theory</td>
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<td>BOT</td>
<td>Build-Operate-Transfer</td>
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<td>CAPM</td>
<td>Capital Asset Pricing Model</td>
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<td>CBA</td>
<td>Cost-Benefit Analysis</td>
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<tr>
<td>CEA</td>
<td>Cost-Effective Analysis</td>
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<tr>
<td>DBFM(O)</td>
<td>Design-Build-Finance-Maintain and/or Operate</td>
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<td>D&amp;C</td>
<td>Design &amp; Construct</td>
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<tr>
<td>DCF</td>
<td>Discounted cash flows</td>
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<td>EPC</td>
<td>Engineering, Procurement &amp; Construction</td>
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<td>GAP</td>
<td>Gross Availability Payment</td>
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<td>HM</td>
<td>Heavy maintenance</td>
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<td>IRR</td>
<td>Internal rate of return</td>
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<td>MAUT</td>
<td>Multi-Attribute Utility Theory</td>
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<td>MAVT</td>
<td>Multi-Attribute Value Theory</td>
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<td>MCA</td>
<td>Multi-Criteria Analysis</td>
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<td>NPV</td>
<td>Net present value</td>
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<td>O&amp;M</td>
<td>Operation &amp; Maintenance</td>
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<td>PFI</td>
<td>Public Finance Initiative</td>
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<td>PPC</td>
<td>Public Private Comparator</td>
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<td>PPP</td>
<td>Public-Private Partnership</td>
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<tr>
<td>PSC</td>
<td>Public Sector Comparator</td>
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<td>PV</td>
<td>Present value</td>
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<td>RISMAN</td>
<td>Risicomanagement en risico-analyse voor projecten</td>
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<td>ROA</td>
<td>Real Option Analysis</td>
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<td>RWS</td>
<td>Rijkswaterstaat</td>
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<td>SAA</td>
<td>Schiphol-Amsterdam-Almere</td>
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<tr>
<td>SMART</td>
<td>Simple Multi-Attribute Rating Technique</td>
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<td>SPC / SPV</td>
<td>Special Purpose Company / Vehicle</td>
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<td>VHB</td>
<td>Van Hattum en Blankevoort</td>
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<td>VW</td>
<td>VolkerWessels</td>
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Bibliography


Appendices
Appendix I Literature Study on Public-Private Partnership

1. Private Involvement and PPP Models

Similar to the ambiguous definition, there is also no single and clear classification of PPP. In practice, various different PPP models have been proposed and due to the dynamic of PPP process, a PPP model is often tailored to a specific context where it is applied. For instance, in the UK, partnership models include asset sale, wider markets, sales of business (by flotation or trade sale), partnership companies, private finance initiative (PFI), joint ventures, concessions, partnership investments, policy partnerships, etc., among which PFI and concessions are the two models commonly used in the UK infrastructure sector. Clearly some overlaps occur in such classification and some of the models are only exist in the UK context.

In the literature, generally PPP is often classified according to the level of the private-side involvement, to be more specific, based on the degree of the risks and responsibilities transferred from the public sector to the private sector. Koppenjan (2008) classifies PPP into three major categories, namely service contracts, build, operate and invest, and state-owned enterprise and joint ventures (see Table A. 1). Based on the legal nature of the private-side involvement, i.e. contract types, DBFM(O), BTO, BO(O)T can be regarded as different forms of PPP (see Table A. 2). PPP can also be broadly divided into two main categories: usage-based and availability-based.

Table A. 1 A spectrum of public-private partnership models

<table>
<thead>
<tr>
<th>Fully public sector</th>
<th>Public-private partnership</th>
<th>Fully private sector</th>
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<tbody>
<tr>
<td>Design</td>
<td>5. Build, operate and invest Concessions</td>
<td>Full divestiture Privatization</td>
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<tr>
<td>Build</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public service provision</td>
<td>Government bonds</td>
<td>Passive public investment Equity Debt guarantees Grants</td>
</tr>
<tr>
<td>Passive private involvement</td>
<td>Government defines the project</td>
<td>Private services provision</td>
</tr>
<tr>
<td>2a. DBFM/O</td>
<td>Private party develops the project</td>
<td></td>
</tr>
<tr>
<td>2b. BOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public investment responsibility</td>
<td>Private</td>
<td></td>
</tr>
<tr>
<td>Provider</td>
<td>Government role</td>
<td>Enabler</td>
</tr>
</tbody>
</table>

Table A. 2 PPP contract types

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74 European Commission 2003
75 HM Treasury 2000; National Audit Office 2009
76 Li and Akintoye 2003; Yescombe 2007; Koppenjan 2008
77 Yescombe 2007
78 Source: Koppenjan 2008 (adapted from Bennet et al., 2000)
In the following part, typical forms of private involvement will be presented and compared.

1.1 Operation, maintenance and management services

Models in this category stand for the least level of the private-side involvement. As the term indicated, private parties only participate in the operation and maintenance phase of existing facilities. The involvement can possibly extend to management of existing facilities. The public sector always owns the facility and is responsible for the investment and the overall management. Service contract, management contract and leasing are commonly used to realize this kind of private involvement. However, Yescombe (2007) pointed out that if the participation of the private party does not include initial construction of new facilities or major upgrading of existing facilities, it should not be considered as a form of PPP but only limited private involvement.

- **Service contract**
  Service contract is a short-term agreement of a few months to a few years that usually only covers the maintenance and operation services and technical systems for existing infrastructure facilities, including toll collection, procurement, operation and maintenance of equipment or technical systems.

- **Management contract**
  Compared with service contract, management contract extends the private involvement from operation and maintenance service aspect to the management of existing assets. The private party can be paid on a fixed fee basis or a performance basis.

- **Leasing**
  In a leasing agreement, besides the scope stipulated in the service and management contract, commercial risk is also transferred to private parties in that they can keep the revenues and make lease payments to the public sector for using the facilities.

1.2 Build, operate and invest

In this category, the private involvement can be realized by using DBFM(O) contract or BOT and its variants. Compared with the operation, maintenance and management service model, in build, operate and invest model, the private party handles more responsibilities.

- **Design-Build-Finance-Maintain (-Operate) – DBFM(O)**

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80 Koppenjan 2008
81 European Commission 2003
82 European Commission 2003; Mu 2008
83 European Commission 2003
84 European Commission 2003; Millones 2010
When DBFM(O) contracts are adopted, the public party defines the project, specifies the desired outputs and the private party is responsible for design, build, finance, maintenance and/or operation. The ownership of the facility always remains in the public-sector side.

Figure A. 1 shows the structure of DBFM(O). A DBFM(O) agreement will be established between the public authority and a Project Company (also called Special Purpose Vehicle, SPV), which is established especially for the project and composed of the private sector actors. The tasks and risks are supposed to be shifted downwards by signing back-to-back contracts with construction and maintenance contractors. Works can be further subcontracted. Shareholder agreements will be signed to clarify the amount of equity and shareholder loan provided by the shareholders. Accordingly, lenders also need to specify the debt terms and amount they provided to the Project Company. Interface contract will be signed to regulate the interface between construction and maintenance. Last but not least, typically a Direct Agreement will be signed between the public authority and the lenders, which provides the lenders with the right to step in when the Project Company defaults or bankrupts.

**Figure A. 1 PPP – DBFM(O) structure (adapted based on Yescombe 2007; Boot, Bruggeman et al. 2008)**

Figure A. 2 shows the equity, debt and income sources and income distribution of the Project Company. There are three main sources of income for the Project Company, namely availability payment from the government, user payment from public users, and government subsidies. In a PPP project, one of the three payment sources or a combination of the three can be chosen. Usually about 90% of funding cost required will be provided by lenders in the form of long-term loan of limited recourse. The rest 10% will be the equity investment and shareholder loan provided by shareholders of the Project Company. During the construction phase, the Project Company needs to pay the construction contractor periodically as pre-agreed, and no repayment or dividend will be committed. When the construction is completed and the facility comes into operation, after paying the operating cost, the Project Company first needs to repay the lenders, and then repay the subordinate loan, finally the left undistributed revenue will be paid to the shareholders as dividend.
- **Build-Operate-Transfer (BOT) and its variants**

  BOT is a form of project financing originating from Turkey in 1980s.\(^{85}\) The private party receives a concession from the public party. During the concession period, the private party usually obtains revenue by charging the public users directly. After the expiry of the concession period the facility will be transferred back to the public sector party. It needs to be noticed that during the operation period, the private side only has the right to operate, but no ownership.

  Different from DBFM(O), in BOT, the financing of the project may still be the responsibility of the public side. If private financing is required, the contract structure of BOT is almost the same as the DBFM(O) except that usually the design work will be contracted to an engineer separated from the construction and maintenance work.\(^{86}\)

  BOT has a lot of variant forms such as Buy-Build-Operate (BBO), Build-Transfer-Operate (BTO), Build-Own-Operate-Transfer (BOOT), and Build-Lease-Operate-Transfer (BLOT), etc.\(^{87}\) Two main variants will be briefly presented below.

  - **Build-Transfer-Operate (BTO)**
    Different from BOT, when BTO is adopted, the private sector party transfers the facility right after the construction. The facility will be operated by a state-owned company or together with the private sector party who built it. The ownership of the facility only remains in the private sector during construction and will be transferred to the public sector immediately when the construction is completed.

  - **Build-Own-Operate-Transfer (BOOT)**
    The private sector party builds the facility, owns and operates it during the concession period, and then transfers it back to the public sector party. The major characteristic of BOOT is that the private sector receives the ownership of the facilities during the concession period.

### 1.3 Joint ventures/State-owned enterprises

In joint ventures, the public and the private sector parties share the responsibilities, risks, profits, and ownerships and therefore are considered to be ‘true’ public-private partnership. The public party

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\(^{85}\) Tiong 1990  
\(^{86}\) Mu 2008  
\(^{87}\) United Nations Economic Commission for Europe 2008
usually plays the role more of a regulator while the private party is responsible for daily operation and management.\footnote{Li and Akintoye 2003}

State-owned enterprises (SOE) are entities operate on behalf of the government, which can be another option to introduce private sector ownership to the public sector. By establishing SOE, the public interest can be preserved and meanwhile financial incentives can also be created.\footnote{HM Treasury 2000}

The contract relationship is similar to the ones established in DBFM(O) and BOT projects. The difference lies in that the Project Company will be a joint venture composed of the private and the public parties or a state-owned enterprise.

1.4 Privatization

Privatization stands for the highest level of private involvement since the public side only participates in the initial phase and during the rest phases of the project, responsibilities, and risks together with the ownership remains within the private sector.

- **Build-Own-Operate – (BOO)**
  In the spectrum of PPP models, BOO is placed at the extreme of privatization. When BOO is used, the private sector party builds the facility, owns and operates it, so BOO has the highest level of the private-side involvement, which can be regarded as privatization.

1.5 Comparison

Figure A. 3 and Figure A. 4 below compare the PPP models and contract types in terms of private sector risks and responsibilities mentioned above respectively. It needs to be mentioned that according to the definition and characteristics concluded in Chapter 1.1.1.1, operation, maintenance and management service will be classified as PPP only when major upgrading of existing infrastructure facilities is involved, otherwise it will be regarded as limited private involvement.

From the two figures above it can be seen that for each form of private involvement, the level of responsibilities and risks transferred from the public sector to the private sector is different. Moreover, for each form of PPP, the private sector is involved in different stages in the project lifecycle, which is shown in Figure A. 5. The private party only involves in the maintenance and operation phases of the project where operation, maintenance and management services are provided. While in the build, operate and invest category, the private party will be involved in almost the whole project life cycle except the project initiation stage.
Figure A. 3 PPP models

Figure A. 4 Contract types used in PPP

Figure A. 5 PPP contracts and project life cycle[^90]

[^90]: Adapted based on Pakkala, W. Martin deJong et al. 2007
2. Research Trend and Topic Coverage

Substantial literature reviews on PPP studies published in leading construction journals have been done by several researchers.\(^{91}\) The research interests in PPP keep increasing, which can be seen from the increasing number of papers published, the expanding range and increasing depth of research topics during the past several years. Topics that have been attracting attention are shown in Table A. 3.

<table>
<thead>
<tr>
<th>Topic category</th>
<th>Sub-topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment environment</td>
<td>Government support, PPP guidelines, workable legal and regulatory framework, government’s attitude, and public perspective, etc.</td>
</tr>
<tr>
<td>Procurement</td>
<td>Project identification, tendering, contract negotiations, concession period, and concessionaire selection, etc.</td>
</tr>
<tr>
<td>Economic viability</td>
<td>Financial feasibility, minimum revenue, minimum feasible tariff, evaluation techniques, and financial capability, etc.</td>
</tr>
<tr>
<td>Financial package</td>
<td>Capital structure, financing source, capital investment, payment mechanism, and debt interest, etc.</td>
</tr>
<tr>
<td>Risk management</td>
<td>Risk identification, risk evaluation, risk allocation, risk management, financial risk, political risk, and market risk, etc.</td>
</tr>
<tr>
<td>Governance issue</td>
<td>Relationship management, stakeholder management, PPP task forces, consortia management, and interface management, etc.</td>
</tr>
<tr>
<td>Integration research</td>
<td>Critical success factors, best practice, positive and negative factors, knowledge innovations, and any other issues excluded from the above categories</td>
</tr>
</tbody>
</table>

It is worth to be noticed that most of the published studies are more public-side- or project-focused. For instance, Zhang (2004) explored how the public authority to select the right concessionaire.\(^{93}\) Ng, Xie et al. (2007) and Albalate and Bel (2009) studied how to assist the public authority to determine the optimal concession period in order to improve social welfare.\(^{94}\) There are also articles devoted to exploring how to establish or improve the institutional framework to achieve successful PPP implementation by analyzing and concluding the critical success factors and learning from advanced experience in countries like the UK.\(^{95}\) Risk assessment and allocation seems to be the main topic for project-focused studies. In comparison with articles that are public-side- and project-focused, there is limited number of studies adopting the perspective from the private-side actors.

In a word, PPP is still a hot topic that attracts attentions of both researchers and practitioners. The concept of PPP needs to be better-understood and a lot of aspects of PPP implementation require improvement. It would be interesting to adopt the perspective of the private-side actors since they are also important players in the PPP market but less research attention has been paid to them.

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\(^{91}\) Al-Sharif and Kaka 2004; Ke, Wang et al. 2009; Tang, Shen et al. 2010
\(^{92}\) Ke, Wang et al. 2009
\(^{93}\) Zhang 2004
\(^{94}\) Ng, Xie et al. 2007; Albalate and Bel 2009
\(^{95}\) Spackman 2002; Chan, Lam et al. 2010
Bibliography


Appendix II Project Selection Criteria in the Literature

The following table concludes the project selection criteria that construction contractors usually consider when making project selection decisions. Their extension to the PPP context is also presented.

Table A.4 Criteria identified in the literature and their extension to the PPP context

<table>
<thead>
<tr>
<th>Category</th>
<th>Criterion (identified in literature, general)</th>
<th>Criterion (in the PPP context)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company-related</td>
<td>Current work load</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experience in similar projects</td>
<td></td>
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<tr>
<td></td>
<td>Development strategy</td>
<td></td>
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<tr>
<td></td>
<td>Confidence in cost estimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relations with other contractors, consultants and suppliers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competitive advantage</td>
<td></td>
</tr>
<tr>
<td>Project-related</td>
<td>Project size</td>
<td>Construction size, maintenance size, investment amount</td>
</tr>
<tr>
<td></td>
<td>Project type/scope</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project duration</td>
<td>Construction period, operation period</td>
</tr>
<tr>
<td></td>
<td>Risk expected</td>
<td>Risk in construction, risk in maintenance, risk in investment</td>
</tr>
<tr>
<td></td>
<td>Project location</td>
<td></td>
</tr>
<tr>
<td>Client-related</td>
<td>Proportion to be subcontracted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reputation of the client</td>
<td>Client type</td>
</tr>
<tr>
<td></td>
<td>Financial capability of the client</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relations with the client</td>
<td></td>
</tr>
<tr>
<td>Competitor-related</td>
<td>Degree of competition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Competence of the expected competitors</td>
<td></td>
</tr>
<tr>
<td>Resource-related</td>
<td>Availability of materials, equipment, and labor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anticipated cost of bid preparation in terms of time and resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Availability of capital required</td>
<td>Availability of required investment capital</td>
</tr>
<tr>
<td>Other</td>
<td>Contract terms</td>
<td>DBFM/BOT contract terms</td>
</tr>
</tbody>
</table>

Bibliography


Appendix III Alternative Projects Introduction

1. N33 Assen – Zuidbroek

The Assen – Zuidbroek section of the National Highway 33 (N33) is a single-lane road located in the north Netherlands, where the traffic flow and safety require to be improved. The contractor is required to realize the expansion of this 42-km road by widening it to a $2 \times 2$ motorway. The construction scope also includes modifying the intersecting infrastructure including a crossing of the Winschoter canal and upgrading the intersections and junctions. A total of 17 structures, including a drawbridge, 2 railway crossings and a viaduct shall be realized. In addition to the design and construction, the contractor shall also perform the maintenance on the N33 between Assen and Zuidbroek for 20 years starting from the completion of construction. The project is availability payment-based, with deductions coming from lane closures and technical failures.

The construction and maintenance sizes of the project are estimated to be about EUR 140 million and EUR 40 million (i.e. EUR 2 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 15 million.\(^\text{96}\)

In terms of stakeholders, the provinces and municipalities who have interests in this project have reached an agreement with the central government to show their cooperation. And there was no resistance coming from the general public. In terms of the construction, the road and civil structure construction within the project scope are considered to be technically very simple. The majority of the construction work will be carried out in green field area instead of fully-built area; therefore the contractor will be faced with much less managerial and technical interfaces. In terms of the maintenance, the contractor needs to carry out the maintenance work of road, civil structures and some simple installations, which is considered to be of a routine work character and is of very low complexity. In terms of project finance, besides banks, institutional lenders such as pension funds and insurance companies are allowed to be involved in the projects to provide funding sources, which increases the diversity of funding sources as well as the financial complexity.

2. A15 verbreden Maasvlakte – Vaanplein (A15 MaVa)

Please refer to Chapter 8.1.1.

\(^{96}\) In this framework practice, all the estimates of project size are derived from the estimates made by the public authority.
3. A12 Utrecht – Maarsbergen – Veenendaal (A12 LuVe)

The A12 LuVe project is an availability payment-based DBFM project, which is similar to the A15 MaVa project but of a much smaller size. The project involves the widening of a 30-km section of the A12 highway from Utrecht to Veenendaal, which includes road and structure construction and upgrade in the following 4 parts:

- Utrecht Lunetten – Bunnik trajectory: from $2 \times 3$ traffic lanes to $2 \times 4$ traffic lanes;
- Bunnik – Driebergen trajectory: from $2 \times 2$ traffic lanes to $2 \times 3$, plus a rush hour lane in both directions;
- Driebergen – Maarsbergen trajectory: from $2 \times 2$ traffic lanes to $2 \times 2$, plus a rush hour lane in both directions; and
- Maarsbergen – Veenendaal trajectory: from $2 \times 2$ traffic lanes to $2 \times 2$, plus a rush hour lane in both directions.

The construction and maintenance sizes of the project are estimated to be about EUR 230 million and EUR 30 million (i.e. EUR 1.6 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 30 million.

In comparison to the A15 MaVa project, this project is considered to be of much less complexity.

4. Schiphol Amsterdam Almere (SAA) corridor program

The SAA corridor program deals with the road expansion of several major highways in the north Randstad area with the objective to improve the traffic flow and ensure the least possible hindrance to the road users and the environment. The whole program is sub-divided into five projects and four of which have been decided to be procured as DBFM projects, namely the A1/A6 Diemen – Almere Havendreef, the A9 Gaasperdammerweg, the A9 Amstelveen Badhoevedorp – Holendrecht and the A6 Almere Havendreef – Almere BO project. Below each sub-project will be introduced. Currently more information is available for the A1/A6 project since it is scheduled to be the first project entering the procurement process.
The SAA A1/A6 project scope includes the construction of a motorway and several new bridges and objects, the re-construction of interchanges, and the traffic management system. In addition to the maintenance during the exploitation phase, the maintenance of the existing infrastructure during construction is also fall in the scope. To be more specific, the contractor is required to fulfill the following tasks:

- To realize capacity expansion:
  - Re-routing and widening of the A1 from 2 × 3 lanes plus two reversible lanes to 2 × 5 lanes plus 2 reversible lanes between the Diemen and Muiderberg interchanges;
  - Expansion of the A6 from 2 × 3 lanes plus peak lane to 2 × 4 lanes plus 2 reversible lanes between Muiderberg interchange and the junction with Almere Stad-west;
  - Expansion of the A6 from 2 × 2 lanes to main and parallel lanes with 4 × 2 lanes between the Almere Stad-west junction and the proposed Almere Havendreef junction.
- Demolition and re-construction:
  - Re-construction of the Diemen interchange;
  - Re-construction of the Muiderberg interchange;
  - Demolition of the old part of A1.
- New construction:
  - Construction of new bridges over the Amsterdam Rijnkanaal and the Gooimeer and of an aqueduct in the Vecht;
  - Construction of two service areas, 5 fauna underpasses, 1 fauna overpass and about 40 new objects.
- The electro-mechanical/dynamic traffic management
- Maintenance
  - Maintenance of existing infrastructure during the construction phase;
  - Maintenance of the entire infrastructure within the scope for 20 years.

The construction and maintenance sizes of the project are estimated to be about EUR 1.3 billion and EUR 210 million (i.e. EUR 10.5 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 156 million.

The project is very complex in terms of both managerial and technical aspects. There are a huge amount of stakeholders involved, namely Provinces of Noord-Holland and Flevoland,
Municipalities of Diemen, Naarden, Weesp, Muiden, Almere, Amsterdam, Water Authorities Zuiderzeeland and Amstel-Gooi-Vecht, Rail infra provider ProRail, Energy network provider TenneT, several nature preserving organizations and the road users. The project technical complexity is high because of a lot of technical interfaces. The construction work includes road construction as well as numerous structures, which requires fully coordination with existing infrastructures and the up-coming SAA sub-projects. Besides, during the construction period, the hindrance to road users should be reduced to the lowest level, which is also a challenge. The technical complexity in the maintenance part during operation phase is moderate because the contractor is mainly required to carry out the maintenance work of roads, structures and the electrical and mechanical installations. Last but not least, due to the large amount of debt that needs to be arranged, a lot of banks will be needed for debt financing.

- **SAA – A9 Gaasperdammerweg**

The scope of this project mainly includes the following tasks:

- To realize capacity expansion by widening the 8-km motorway from 2 × 2 lanes plus rush-hour lanes to 2 × 2 lanes plus 1 contra flow lane and a parallel road consisting of 2 × 3 lanes;
- Re-construction of the Holendrecht Noord junction;
- Construction of the Gaasperdammerweg tunnel with the possibility to build housing above.

The construction and maintenance sizes of the project are estimated to be about EUR 900 million and EUR 125 million (i.e. EUR 6.25 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 110 million.

The complexity of this project in terms of management, technical and financial aspects is considered to be similar to the SAA – A1/A6 project. Several 3rd parties with interests in the project are involved, which includes City Borough Amsterdam Zuid-Oost, and City of Amsterdam, the Water board, environmental and monumental organizations, and the citizens. Carrying out work within a built area will lead to numerous management and technical interfaces. The construction work also includes building the Gaasperdammerweg tunnel. The high required-quality of the tunnel and safety specifications that the tunnel needs to fulfill increases the technical complexity. Besides, in the current development plan, the public authority has the intention to realize the possibility of area development above the tunnel, which could make the project become even more complex. In terms of maintenance, in addition to the road, structures, and road installations, tunnel installations could possibly also fall in the scope, therefore the maintenance technical complexity would be high.

- **SAA – A9 Amstelveen Badhoevedorp – Holendrecht**

The project is considered to be fully in line with 3 VW subsidiary company’s business scopes, which mainly includes the following tasks:

- To realize capacity expansion by widening the 12-km motorway from 2 × 3 to 2 × 4 lanes plus 1 contra flow lane between Holendrecht and the Bullewijk;
- Re-construction of the Holendrecht junction;
- The petrol station on the north side of the A9 near Amstelveen will be moved westward and the one on the south side near Amstelveen will be moved eastward and will be expanded;
- Integration with 2000-meter tunnel and the area development above;
- Installation of sound barriers.

The construction and maintenance sizes of the project are estimated to be about EUR 900 million and EUR 125 million (i.e. EUR 6.25 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 110 million.

Limited information is available for this project and it is estimated to be of more or less the same complexity as the A9 Gaasperdammerweg project due to the similarity in terms of both project scope and size.

- **SAA – A6 Almere Havendreef – Almere BO**

  The project is considered to be fully in line with 3 VW subsidiary company’s business scopes, which mainly includes the expansion of the A6 from 2 × 2 lanes to main and parallel lanes with 4 × 2 lanes between the Almere Havendreef and Almere BO.

  The construction and maintenance sizes of the project are estimated to be about EUR 500 million and EUR 70 million (i.e. EUR 3.5 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 60 million.

  Limited information is available for this project and it is believed to be of much less complexity than the other three SAA sub-projects.

5. **North-South route in Limburg (Belgium)**

The North-South route in Limburg is a Belgium DBFM project. The project is located in the area near the Dutch border. The project scope includes the construction of the new part of the North-South route N74 from Heikantdreef in Hechtel-Eksel to the existing part of N74 ends in Hasselt, which will intersect with the East-West route E314. The project mainly involves road construction and 3 cut and cover tunnels. The project is to be procured in the form of a DBFM contract of execution period plus a 30-year long operation period.

  The construction and maintenance sizes of the project are estimated to be about EUR 315 million and EUR 45 million (i.e. EUR 1.5 million per annum) respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 38 million.

  Technically the project is not very complex since a large part of the infrastructure will be built in green field area with fewer interfaces. And the technique required for tunnel construction is also considered to be simple. However, there has been serious resistance coming from the general public and some environmental organizations to the current project plan.

6. **Groningen RegioTram**

The Groningen RegioTram project comprises all work and services to be provided under the DBFMO agreement in relation to the design, building, financing, maintenance and operation of the complete systems, comprising RegioTram Lines 1 and 2 in the Municipality of Groningen, including the required tram infrastructure, rolling stock, and the design and construction of the municipal infrastructure located within the work boundaries. The project is availability payment-based and the

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97 Source: [www.regiotram.nl](http://www.regiotram.nl)
clients are the Municipal Council of Groningen and the Provincial Executive of Groningen. The operation period is planned to be 22.5 years.

Figure 37 Groningen RegioTram

The construction and maintenance sizes of the project are estimated to be about EUR 307 million and EUR 3 million per annum respectively. The total funding amount that requires shareholders to handle is estimated to be about EUR 36 million.

The project is considered to be very complex since the contractor needs to deliver a brand-new tram system in the city center. One challenge is that the hindrance level to the traffic alongside the tram lines should be reduced to the lowest level.
Appendix IV Interviewee List

1. Interviews focusing on the general background of PPP
   - Ing. R.F.A. de Ridder (Director VolkerInfra Asset Management, VolkerInfra)
     Asset management and maintenance in DBFM projects
   - Mr. J.G. Schillemans (Manager PPP, VolkerInfra)
     Motivation of the Dutch State government to launch PPP projects, government’s requirements to contractors
   - Ir. A.H. Naafs (Director VolkerInfra PPP, VolkerInfra)
     All practical aspects about PPP with focus on financing, weekly discussion

2. Interviews focusing on the application of risk analysis
   - Ing. F.C. Nibbering (Tender Manager, VolkerInfra)
     Risk analysis in bid preparation with focus on the EPC part of the A15 MaVa project
   - Ir. D. Kuiper (VolkerInfra, Process Manager)
     Risk analysis in bid preparation

3. Interviews focusing on the framework application
   - Ir. M.S. Bakker (Director VolkerInfra, VolkerInfra)
     Representing the construction and maintenance contractor roles
   - Ing. R.J. Brouwer (Director of Projects, VHB)
     Representing the construction contractor role – road and civil engineering part
   - Ir. E.P. Stoelinga MBA (Senior Manager PPP, VolkerInfra)
     Representing the construction contractor role – rail part
   - Ing. R.F.A. de Ridder (Director Asset Management, VolkerInfra)
     Representing the maintenance contractor role
   - Ir. A.H. Naafs (Director VolkerInfra PPP, VolkerInfra)
     Representing the equity investor role
   - Mrs. A. den Otter (Director Treasury & Finance, VolkerWessels)
     Representing the equity investor role
   - Ms. C.M.C.M. Appels (Project Finance Manager, VolkerWessels)
     Representing the equity investor role

4. Interviews obtaining general feedback
   - Dr.ir. A.R.M. Wolfert (Senior Advisor Process / R&D, VolkerInfra)
     General feedback and comments on the thesis
Appendix V Model Setup – Project Screening Part

Front-stage sheets:

- Alternative information input sheet

  The alternative information input sheet is structured in the form of a questionnaire, where general information and criteria-specific information are required in the Excel model.

  ![Alternative information input sheet](image)

- Alternative score output sheet

  The alternative score output sheet presents the individual scores, scores per role and the overall score of the alternative. The scores are values obtained automatically based on the information inputted and the value functions and weights stored in the back-stage sheets. The scores per role and the overall score take decision makers’ priorities into consideration.
Back-stage sheets

- **Value function sheet**

  The value functions for criteria with continuous consequences are stored as user-defined formulas in the model. Other value functions are stored directly in the value function sheet.

- **Criteria pair-wise comparison, criteria weights calculation, and criteria weights outcome sheets**

  The criteria pair-wise comparison sheet stores the decision makers’ pair-wise comparison results obtained from the questionnaire. Table A. 5 shows an example of the questionnaire designed for criteria pair-wise comparisons. The pair-wise comparison matrices derived by the pair-wise comparisons are calculated in the criteria weights calculation sheet, so as the aggregation matrices. The outcomes are presented in the criteria weights outcome sheet.

- **DMs pair-wise comparison, DMs priorities calculation, and DMs priorities outcome sheets**

  These sheets are structurally the same as the three criteria weights-related sheets, except now the DMs are being compared in terms of their priorities for each criterion. For each criterion, first the roles involved are compared, and then within each role, the decision makers are compared.
### Example questionnaire – criteria pair-wise comparisons

<table>
<thead>
<tr>
<th>Criterion A</th>
<th>A is extremely more important than B</th>
<th>A is strongly more important than B</th>
<th>A is moderately more important than B</th>
<th>A is slightly more important than B</th>
<th>A and B are equally important</th>
<th>B is slightly more important than A</th>
<th>B is moderately more important than A</th>
<th>B is strongly more important than A</th>
<th>B is extremely more important than A</th>
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Appendix VI Model Setup – Individual Project Evaluation Part

The purpose of this model is to illustrate how the second part of the framework can be applied to real cases. The main question that the model aims to provide answers to is within the ceiling price, whether the bid currently developed can generate satisfactory return to each role when risks and uncertainties are being considered. The following part explains the model setup in detail.

An already-delivered bid of the A15 MaVa project was simplified to be used as the case. Due to confidential reasons, the assumptions in relation to specific bidding and pricing strategies that were used in the model are not listed here.

**Inputs:**

- Cost estimate

A rough EPC, O&M, SPC and heavy maintenance costs estimate was made. The standard uncertainty caused by inaccuracy of cost estimate during the tender phase was considered, which is modeled in the way that the minimum value was 95% of the base case, and the maximum value was 110% of the base case. Figure A. 8 shows part of the cost estimate sheet. The cells in yellow are input cells and the cells in green are Crystal Ball assumption cells where estimate inaccuracy was modeled as triangular distribution.

![Figure A. 8 Extract from the cost estimate sheet](image)

- Project schedule

A rough project schedule including several major tasks was made and inaccuracy in duration estimate was modeled using triangular distribution. Figure A. 9 shows part of the project schedule sheet. Some task precedence and dependence relationships were defined roughly. For instance, it is defined in the model that the construction work can only start after obtaining the permit and
finish conditioning. It is assumed that the interim availability date is the construction completion date of the Trace West, and the availability date is the end date of the whole construction period.

<table>
<thead>
<tr>
<th>Task</th>
<th>Start date</th>
<th>Base case Duration</th>
<th>Consider uncertainty</th>
<th>Risk consequences on duration</th>
<th>End date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction phase</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Start</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>August 29, 2011</td>
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<td>600</td>
<td>September 27, 2011</td>
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<td>Get permit Trace West</td>
<td>January 1, 2011</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>September 8, 2011</td>
</tr>
<tr>
<td>Get permit Botlek corridor</td>
<td>January 1, 2011</td>
<td>280</td>
<td>280</td>
<td>280</td>
<td>October 6, 2011</td>
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<tr>
<td>Get permit Trace Cost</td>
<td>January 1, 2011</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>September 8, 2011</td>
</tr>
</tbody>
</table>

Figure A. 9 Extract from the project schedule sheet

- Risk analysis

Specific event risks were modeled using discrete distributions for the probability of occurrence, and triangular distributions for the consequences on cost, duration and availability. A certain risk can happen to several tasks and for each task, the assumptions are made separately. The consequences on cost and duration are correlated since usually longer duration would lead to higher cost.

Figure A. 10 Extract from the risk analysis sheet

Inflation was modeled using triangular distribution and the minimum, maximum and most-likely values were estimated based on the history data.

98 In reality, it is not necessary to start construction only after obtaining all the permits and finish all the conditioning work. The three tasks can be found proceeding simultaneously. Usually at a more detailed level, the precedence and dependence relationships between the tasks will be defined. Here the tasks interdependencies were defined roughly for illustration purpose.
The estimated costs were clustered according to the tasks in the project schedule. Macros were programmed to realize automatic cost and revenue allocation in accordance with the project schedule.

- **EPC cash inflows**

  EPC cash inflows are the payment from the SPC, which is the EPC bid price proposed by the EPC contractor. EPC cash inflows will be influenced by risk consequences on availability and will not be indexed.

- **EPC cash outflows**

  EPC cash outflows are the construction cost, which will be influenced by risks, uncertainties and inflation.

- **O&M cash inflows**

  O&M cash inflows are the payment from the SPC, which is the O&M bid price proposed by the O&M contractor. It will be influenced by availability deduction. O&M cash inflows during the construction period will not be indexed, but the cash inflows during the operation period will be indexed.

- **SPC cash inflows**

  SPC cash inflows are the lump sum payment and the GAP from the public authority. SPC cash inflows will be influenced by risk consequences on availability but will be transferred to the EPC or O&M contractors. The GAP during the operation period will be indexed. Here in this model it

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is assumed the discounted GAP and lump sum payment equals to the ceiling price. In other words, we assume that the company will present a bid with overall price equal to the ceiling price.\textsuperscript{100}

- SPC cash outflows

SPC cash outflows are the payment to the EPC and the O&M contractors as they proposed in the EPC and O&M bid, plus SPC operation cost and heavy maintenance costs. Payment to the O&M contractor during the operation phase will be indexed. The SPC operation cost and HM costs will be influenced by risks, uncertainties and inflation.

**Output calculations:**

- EPC and O&M profit margins

First of all, the prices of the EPC and O&M bids were determined based on the assumed pricing strategy, i.e. the amount of contingency and profit markup added were calculated based on the assumptions. Then, with the proposed bids, simulations were carried out to obtain the probability distribution of the profitability indicators.

- EPC profit margin
  
  \[
  \text{EPC profit margin} = \frac{\text{actual income} - \text{actual cost}}{\text{actual income}}
  \]
  
  Actual income = bid price – availability deduction
  
  Bid price = cost estimate base case + profit markup + contingency for risk, uncertainty and inflation

- O&M profit margin
  
  \[
  \text{O&M profit margin} = \frac{\text{actual income} - \text{actual cost}}{\text{actual income}}
  \]
  
  Actual income = bid price – availability deduction + indexation during operation period
  
  Bid price = cost estimate base case + profit markup + contingency for risk and uncertainty

- Equity IRR

A simplified financial model was developed for calculating the equity IRR, which evaluates the project from the perspective of the equity investor of the SPC. The equity IRR calculated here is the pre-tax nominal IRR, which is calculated based on the equity invested and the dividends received.

- Expenditure
  
  The EPC bid price and HM cost are inputs for capital expenditure, while the O&M bid price and SPC cost are inputs for operating expenditure. All inputs are nominal values, i.e. taking inflation into account.

- Capital structure
  
  Only debt and equity were considered in the model. The equity will be redeemed when the contract expire. The interest during construction period and the arrangement and commitment fees for senior debt are capitalized. Only the EPC cost, the capitalized financing costs and the first amount of balance required for the two reserve accounts (see below) were funded.

\textsuperscript{100} In reality, companies would probably bid lower than the ceiling price to be more competitive, which depends on companies’ bidding strategies.
Senior debt repayment
During the construction period, the lump sum payment will be used to repay the principal. No financing costs will be paid during the construction phase. As from the operation period, each year the planned debt service is of the same amount.

Amortization
Since the SPC does not have the ownership of the facility to be built, what it receives is a contract asset. According to IFRIC 12, such asset should not be depreciated as fixed asset, but needs to be treated as financial asset through profit and loss account. Here for simplification purpose, it is assumed that the contract asset will be amortized with a residual value of zero when expiry.

Reserve accounts
Two reserve accounts were modeled, namely the major maintenance reserve account (MMRA) and the debt service reserve account (DSRA). Each year the SPC reserve certain amount of cash to finance the up-coming HM costs. The DSRA is required by the bank to cover a certain period forward of debt service.

Financial statements
All the sheets mentioned above resulted in the three financial statements, namely the balance sheet, the income sheet and the cash flow statement, which are the basis for equity IRR calculation.

Sensitivity analysis:
The base model for simulation was established using the most-likely value of all the assumptions, which was also used as the base case for the sensitivity analysis.