Graduation thesis report
Delft University of Technology

A multi criteria method for bid / no bid decision making based on competitiveness – the case of TBI

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Preface

This report is the culmination for my graduation research for the master Construction Management and Engineering.

I would like to thank my parents enabling me to study all these years. Especially my father for asking me one important question two years ago, opening an avenue to a master in Construction Management and Engineer. My brother Rik deserves another special mention, always ready to help; be it remodelling a house, mathematics and for valuable advice on this thesis. I also want to thank Eline for being there in times of need, always listening to me rambling about my thesis and still managing to ask important questions.

Furthermore I would like to thank Robin de Ronde for laying the groundwork for a graduation position at Croon - TBI and Martin Kleintunte for being a wonderful supervisor. You brought me into contact with a number of decision makers at multiple sister companies which helped shape this research. I would also like to thank Jan-Maarten Cornet for providing me with a database of contracts to pick from and for his delightful comments and questions.

Finally I would like to thank my graduation committee for being ready at all hours, even during the holidays, and providing much needed feedback. You were always on point and did not shy away from giving feedback. For you, and all those not mentioned: thank you.

I hope you will enjoy reading this report.

Robert-Jan van Dijk

The master has failed more times than the beginner has even tried.

- Stephen McCranie -

A multi criteria method for bid / no bid decision making based on competitiveness – the case of Croon

By

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Executive summary

The cost of participating in large infrastructure tenders is large, and needs to be recovered regardless of winning or losing. Contractors are ill-equipped to identify projects on which they are competitive, relying mostly on gut feeling or incomplete models. This needs to improve to increase the probability of winning, and decrease the cost of working on unfeasible projects.

The main objective of this research is:

- *The development of a tool which structures the bid / no bid decision, including identification of relevant bid / no bid factors as well as the most important project competitiveness factors.*

The multicriteria method Evamix was selected as the comparison method to determine the attractiveness of a project. It is most applicable to this decision making problem because it can compare both quantitative and qualitative criteria and creates a ranking of projects whilst remaining relatively transparent to decision makers.

Evamix is used to compare the nineteen factors in a bid / no bid decision making tool. Over 200 factor were identified in the literature. These factors were extracted and combined using a variety of methods. Resulting in the following factors covering the bid / no bid decision:

- Partners
- Experience
- Contract size
- Job Type and size
- Risks, Uncertainty & Complexity
- Experience and strength of the firm
- Quality and availability of assets
- Economic conditions
- Competition
- Workload
- Client type
- Location
- Innovations
- Specialization
- Complexity
- Profitability
- Design & Document quality
- Client Financial
- Client Relations

Of the nineteen factors identified five were found to be of critical importance to Croon's competitiveness using five case study projects. These five factors can be quantified and standardized using Evidential Reasoning rules. For the other factors qualitative decision rules have been established.

All identified factors are used in a pairwise comparison with Croon's decision makers to determine their preference. Experience is deemed the most important, followed at a distance by Quality of Assets, Partners and Innovation. One of the decision makers was willing to provide more information about his preferences, this was used to determine a final weighting for all factors using pairwise comparisons and the Analytical Hierarchy Process.

The factors, weights and standardization rules were all used to design a bid / no bid decision making tool which was tested on two Bicycle storage projects tendered for by Mobilis. The results are presented using a success score and colour coding to optimally inform decision makers. Finally a constituent score is generated for all factors which ranks the performance on every factor separately.

The resultant tool is robust based on three sensitivity analysis methods, showing only slight deviations for five out of the nineteen used factors.

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1. Introduction and Demarcation

In this chapter the topic of this research is introduced. First a description of the state of the Dutch construction industry is given. This leads to a problem definition and a number of objectives and research questions. In the demarcation the projects and type of factors used for this research are defined. Finally this chapter contains an outline of the following document.

1.1. Introduction & the construction industry

The Dutch construction industry used to be characterized by strong price competition on local markets by a large number of small firms and a few large ones(Bremer & Kok, 2000). Infrastructure construction is an especially highly concentrated sector of construction with an equivalent of seven contractors competing for contracts based on the Herfindahl-Hirschman Index(Chiang, Tang, & Leung, 2001). The introduction of procurement legislation aimed at stimulating innovation has led the Dutch construction industry to transition to integrated contracts(Boes & Dorée, 2011) and the introduction of European regulations for supplier selection has led to a focus on cost and quality rather than cost alone(Bergman & Lundberg, 2011).

According to Doree (2004) Dutch contractors were (partially) reimbursed for the costs incurred in bidding until 1992. New procurement rules removed reimbursement. This is seen as one of the factors leading to the 'Bouwfraude' - the largest collusion scandal in Dutch history –that was discovered in 2002. Construction firms would systematically share bidding information and the costs of preparing a bid were reimbursed by the 'winning' contractor(Dorée, 2004). This practice has since been abolished, but the high costs – a motivator for ill intent - of preparing a bid remain.

In the past years Imtech, the largest installation company in The Netherlands, has gone bankrupt. Ballast Nedam, a construction behemoth, was only just spared the same fate. Other large construction companies have been operating with low margins for years(Ballast Nedam, 2015; Koninklijke BAM Groep, 2015; TBI, 2015).

Combined with European and national legislation specifying the usage of the Economically Most Advantageous Tender (EMAT) method for evaluating bids the market structure for infrastructure projects – which are almost always procured by governmental agencies - has changed since Bremer and Kok's classification.

Under EMAT low prices are no longer the only factor used for contractor selection. Based on Porter's (2008) competitive model this implies contractors need to compete on other dimensions, such as support, product features or delivery time. In a market dominated by fierce competition selection of contracts to bid upon, where the contractor can provide a unique dimension, is becoming more important.

1.1.1. Problem description

The cost of participating in large infrastructure tenders - regardless of winning or losing - is large. According to Halpin(2010) 0,25% of the contract price can be incurred by the contractor, increasing with complexity. With a yearly market of around €7 billion, the total cost of bidding by all contractors in the market can be estimated at a minimum of €120 million per contractor. These costs need to be recovered by contractors, which increases their markup as well as the total cost of infrastructure to society(Halpin, 2010, p. 26).

This is not desirable, as it leads to higher costs on other projects; money spent needs to be recovered. With multiple contractors competing the costs made by losers can skyrocket as is evidenced by industry magazine Cobouw for architecture (van Belzen, 2016). Furthermore losing these projects demotivates the staff who have been working on the project for prolonged periods of their careers.

Contractors are ill-equipped to identify projects on which they are not competitive. Tools available are either unusably complex, or not used at all, and gut feeling determines the bid / no bid decision. This needs to improve to decrease the costs of writing tenders, in turn leading to healthy profits for contractors, and less expensive infrastructure.

This thesis addresses this problem as follows: *The cost of participating in large infrastructure tenders is large, and needs to be recovered regardless of winning or losing. Contractors are ill-equipped to identify projects on which they are competitive, relying mostly on gut feeling or incomplete models. This needs to improve to increase the probability of winning, and decrease the cost of working on unfeasible projects.*

1.1.2. Objectives

Coupling of the extensive field of competitiveness to the less investigated field of bid / no bid decision making can expand the current literature. It is expected this will lead to the creation of a tool which identifies and ranks opportunities before the bid / no bid decision has been made, based on the expected competitiveness for the project. Presently such a (scientific) tool does not exist.

The tool should rank projects based on the chance to score a project. It is expected this tool can assist in decreasing unnecessary costs made for bid proposals by providing a method and tool for evaluating upcoming opportunities.

The main objective of this research is:

- The development of a tool which structures the bid / no bid decision, including identification of relevant bid / no bid factors as well as the most important project competitiveness factors.

This objective includes three sub goals;

- Identifying key variables which influence a contractor's competitiveness and bid / no bid decision making by doing a literature study.
- Decrease costs of unnecessary bids to society by improving project selection using a bid / no bid tool based on competitiveness.
- To couple the bid / no bid decision making to competitiveness theory by integrating competitiveness into the tool.

The first stage of the research; the identification of factors, is done through interviews and literature research. After the relevant factors have been found they will be confronted with each other using a database of contracts obtained from a contractor. The final stage of the research is designing and validating a tool which ranks contract opportunities based on the expected competitiveness of the bid.

1.1.3. Main & sub questions

To reach the objectives the following research question has been developed: *What bid / no bid and competitiveness factors are the most important for project level competitiveness based on EMAT ranking of large infrastructure projects and how can bid / no bid and competitiveness factors be utilized when making a bid / no bid decision.*

To answer the research question and reach the objectives the following sub questions need to be addressed:

- What method is best suited for comparing and ranking projects?
- What factors critical to bid / no bid decision making and competitiveness can be derived from theory?
- Which identified factors influence competitiveness on case study projects?
- What factors are most important to decision makers?
- How can the identified bid / no bid and competitiveness factors be utilized to improve the bid / no bid decision?

1.2. Demarcation

This research is concerned only with **project** competitiveness, defined as one of the levels of competitiveness by Flanagan, Lu, Shen, and Jewell (2007). The project level has been selected because according to Flanagan et al. (2007) this level has relatively little research associated with it. Furthermore projects form the core of a construction companies day to day tasks.

Because firm and industrywide factors are not included, strategic long term competitiveness factors are excluded. This implies the project level factors considered should be **tangible** and **available now** and not intangible factors such as learning capacity or human resource development programs.

For the bid / no bid factors only **criteria** employed in decision making are scrutinized for their effect on competitiveness. The bid / no bid process will not be investigated because processes are different in every company, and obtaining enough influence to implement changes to the process is highly unlikely for a graduate student / intern.

The problem owner for this research is Croon Elektrotechniek, a large Dutch electro technical installations company. After losing a number of large, high profile infrastructure EMAT tenders the company signaled it had a problem. Croon supplies a database of projects, as well as in-depth information about select projects for the purpose of this research.

Finally only EMAT tenders with a contract value of over €5.000.000 are considered. This ensures complex jobs with a large tendering value are considered; the highest gain can be obtained for these types of projects. Furthermore the boundary of €5.000.000 reflects the maximum value for which EMAT is not required. EMAT tenders are generally more complicated and require more effort from the contractor. Finally the projects should be for integrated contracts, not just maintenance or construction. It is expected more improvements can be found for these tenders than those for recurring contracts such as winter maintenance.

All projects should be located in the Netherlands to reflect the Dutch legal system, and to ensure Croon has relevant experience in the local economic climate.

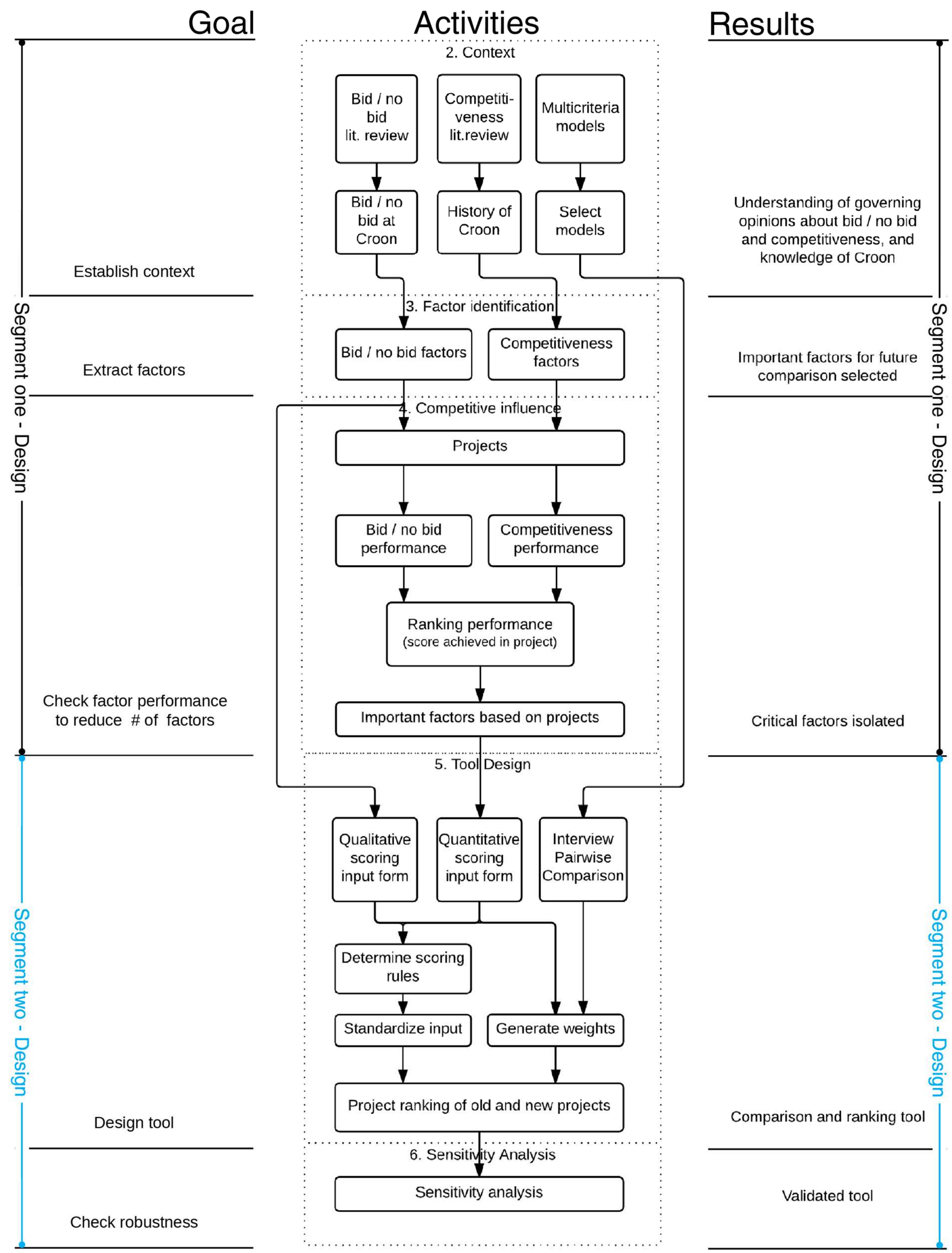


Figure 1.1: Research methodology with chapter goals and results

1.3. Document structure

In this section the document structure of this report is described. Figure 1.1. provides an illustration to the document structure described below. This chapter holds the problem statement, objectives and research questions as well as the demarcation of the research topic.

As can be seen on the left side in figure 1.1. this research is split into two segments, a third segment holds the conclusion and implications. The first segment deals with identification of important factors in chapter's two to four. In the second segment, chapter five and six, a bid / no bid tool is designed and validated. Below a short description of the research carried out in each chapter can be found.

Chapter two provides the context within which this research is conducted. It provides a short literature review of competitiveness and bid / no bid, as well as a characterization of the bid / no bid process at Croon and the company's core competencies based on history. Finally a comparison and ranking method, which will function as the backbone for the tool, is selected.

In chapter three bid / no bid and competitiveness factors are extracted from the literature. These factors are tested for their influence on competitiveness using projects in chapter four.

The influential factors are used for determining scoring rules for quantitative factors in chapter five. The other factors i.e. those that were not influential, or deemed not applicable to the projects (in chapter three) **return in chapter five as qualitative factors** important to the bid / no bid decision. These factors are then standardized, a weighting is generated and an assessment and advice is generated to determine the desirability of a project, thus completing the tool.

The tool is then applied to both old and new projects, and in chapter six a sensitivity analysis is undertaken.

Chapter seven, eight, nine and ten hold the conclusions, discussion, limitations and finally recommendations.

Segment one - Analysis

The first section of this report contains the context for the remainder of the report as well as identification of key project competitiveness factors. Chapter two starts off with a literature review on competitiveness and bid / no bid decision making and an ends with an introduction of Croon Elektrotechniek - the project owner of the case study projects - and it's bid / no bid decision making methodology.

In chapter three and four bid / no bid and competitiveness factors found in the literature are systematically combined and analysed for their influence on project competitiveness. Chapter three deals with identification and combination, whilst chapter four holds the case study where key project competitiveness factors are separated from non-influential factors.

Figure 2.0: Fish for sale at the Tsukiji fish market. Source: J. Judge (2011) retrieved from https://eclecticlimpet.wordpress.com/2011/07/01/the-tsukiji-fish-market-a-feast-for-the-eyes-the-stomach-and-the-mind/

2. Context

This first chapter of section one provides the context for the remainder of this report. Firstly competitiveness and bid / no bid decision making are defined using a literature review. After the literature review the company profile of Croon Elektrotechniek B.V. (Croon) the company which provides project information, and its bid / no bid process are examined. The final section of this chapter selects the type of model and a method from that type to use for designing the proposed bid / no bid tool.

2.1. Theory and Practice

Two topics need to be established first; the definition of competitiveness and the bid / no bid decision. Both subjects will be addressed using a literature review in this section.

The second topic in the Context chapter is Croon Elektrotechniek, its history and the methods it used for bid no bid decision making. In the subsequent chapters important factors for the bid / no bid decision and competitiveness will be extracted and tested for their influence on competitiveness. Some factors Croon finds very important might be excluded because they have little or no effect on competitiveness. This section serves both as a company background, as well as a method for identifying Croon Elektrotechniek's competitive and bid / no bid focus.

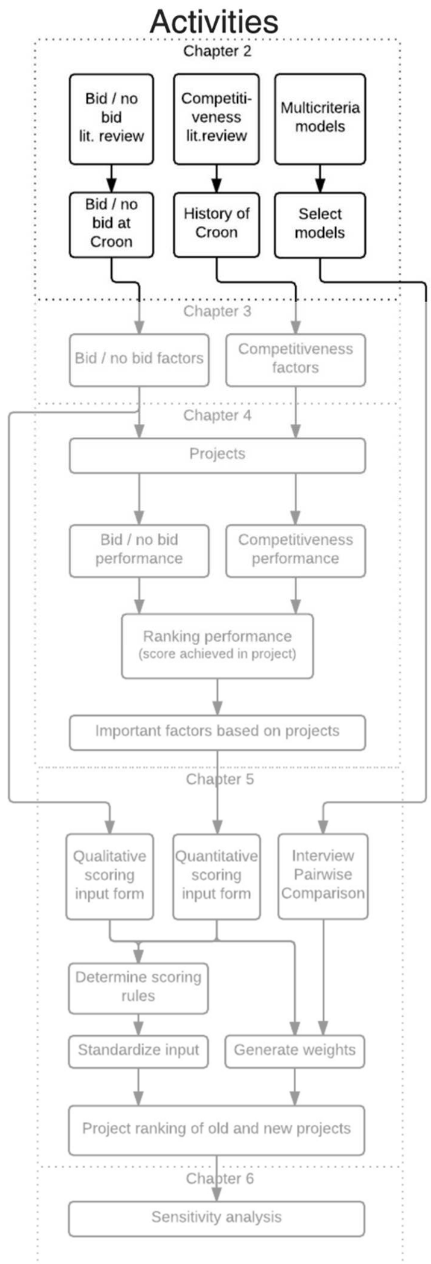


Figure 2.2: Position of chapter two in the research methodology.

2.1.1. Competitiveness

A lot has been written about competitiveness in the past 50 years. The most popular framework and interpretation to understand competitiveness and the implications it has for a firm is the five forces model by Porter(2008), introduced in his seminal article of 1979. In this article he identified market conditions and characteristics of the company itself – products and services it provides - as the driving force behind the competitiveness of a company.

As the objective of this research is to improve performance of the bid / no bid decision such a broad definition is not applicable for obtaining factors explaining competitiveness; it creates a high level abstraction and framework for understanding rather than a thorough explanation. In the following section competitiveness for the construction industry is defined and a history of Croon leads to a description of its core competencies and identification of it's competitive character.

2.1.1.1. What is construction competitiveness?

According to Henricsson, Ericsson, Flanagan, and Jewell (2004) little regard is given for understanding what competitiveness is. Their report focusses on competitiveness on an industry level, but they provide some insight into competitiveness of a single firm. According to Henricsson et al., when citing the Aldington Report, a firm is competitive when "[It] can produce product and services of superior quality and lower cost than its domestic and international competitors".

Lu (2006), after analysing competitiveness literature, proposes three assertions that define competitiveness for a construction firm

"Firstly competitiveness should enable contractors to win construction project and should therefore incorporate the ability for competitive bidding. Secondly competitiveness is developed by the services contractors provide [the projects they build]*. Finally a competitive contractor should achieve superior performance of the firm in the long run."*

This research is mostly concerted with the first part of the definition by Lu. Contractors are (seemingly) unable to repeatedly bid successfully on project they can win. Improving competitive bidding using the proposed model would improve the contractors competitiveness. The other components Lu describes are all influenced by long-term processes and therefore less interesting to this research.

According to Flanagan et al. (2007, p. 996) competitiveness is seen as a contractor's ability to compete for a project where the contractor is selected on a multicriteria basis. It is argued a public sector client is essentially comparing competitiveness between competing contractors (Shen, Li, Drew, & Shen, 2004, p. 385).

Competitiveness is not only based on the commitments made in a bid, but also by a firm's previous experience, capacity and the characteristics of the local market. In reviewing the literature Flanagan et al. (2007, p. 997) find an abundance of sources detailing methods for identifying the best contractor, but a shortage of literature helping contractors maximise their competitiveness for construction projects.

Competitiveness is generally understood on a number of levels. The *firm* level is most established, with identification and testing of success factor in China and Chile (Lu, Shen, & Yam, 2008; Orozco, Serpell, & Molenaar, 2011). The *nation* and *industry* level also receive attention by (Henricsson et al., 2004) and (Shen et al., 2004) respectively.

2.1.1.2. Conclusion

Competitiveness for the construction industry is a firm's ability to bid and win, which is developed by building projects and leads to a long term superior performance. Competitiveness embodies those distinctive qualities clients look for possessed by firms on multiple levels. Of these levels the project level is least developed. Furthermore development and improvement of performance of a built project is not included in this research, in line with the demarcation.

2.1.1.3. Core competencies – History Croon Elektrotechniek

When addressing the decision to bid the first items to be taken into consideration are the fit between the competencies a project requires and competencies Croon has. These core competencies are not written down and in discussions with employees there was no uniform picture. However, company history can provide an insight into the competencies and character of Croon.

Croon was founded in 1876 in Amsterdam by B.H. Croon, who worked as a telegraph operator for the city of Amsterdam. He founded his own company building, selling and installing some of the first telephones. As the city electrified Croon was part of installing residential circuits, and lighting became a part of business. Notable works include the installation of telegraph equipment on Royal Cruisers, and lighting the construction of the 'Noordzeekanaal' near Amsterdam. As B.H. Croon approached old age Croon Amsterdam was closed, but the Rotterdam establishment led by his son remained profitable.

Up to the Second World War Croon saw an expansion of its activities, selling vehicles, Telefunken radios, primitive televisions, and installing numerous residences, navy ships, factories and utilities such as the Rotterdam Zoo. The navy installation contracts were particularly lucrative, as a transition was made from steam based to mechanized propulsion.

During the war Croon was tasked with installing the lighting in a number of emergency shops, as well as the emergency theatre. A generator is smuggled and installed at a local hospital, which had the added benefit of charging batteries for residences.

After the war Croon is responsible for 'demagnetising' installations for ships, which remove the magnetic signature of a ship, making it safer to pass minefields. Croon also acquires commissions to import engines, transformers and cranes to aid in rebuilding the country. Commissions to construct luxury passenger ships and the installation of numerous Royal Marine ships forms the most core of Croon's work during the reconstruction. In the 1950's and 1960's Croon also installed an oil refinery, built 34 carriages for the Rotterdam tram company and opened a wholesale- division and -store. Finally Croon acquired the right to use Pyrotenax fireproof cabling.

The company, at the time still governed by descendants of B.H. Croon, was becoming too large for the family. They were only financially affiliated to the firm, and no longer involved in day to day operations.

In the 60's Croon installs a large number of diverse ship types, dredgers, cruise ships and tankers as well as bridges and sluices. Other land installations include the Delft Nuclear Reactor, a laboratory for Shell, a factory for Heineken and supermarkets for Albert Heijn. A joint venture with an American company results in the construction of fridges for supermarkets and grills for restaurants.

In 1959 75% of Croon en co. was sold to the Dutch Overzeese Gas- en Electriciteitsmaatschappij (OGEM). After the takeover Croon rapidly expands utilizing takeovers and lobbying for regional peer to join the 'Croon group'. The expansion causes the focus to shift from waterborne installations. In the decade after the war 50% of revenue came from ships, in the 1970's this was reduced to 25%. In 1964 the remaining 25% of Croon is sold to OGEM. In 1970 the revenue of Croon for the first time surpasses 100.000 guilders, a hundredfold expansion has been generated in 25 years.

This can be partially attributed to the expansion drive OGEM, and with it Croon had. This proved to be the downfall of OGEM in the end. A large number of acquisitions were funded with debt, and when the 1980's recession hit OGEM's financially sound companies were restructured in Techniek Bouw Infra (TBI). Croon was integrated into TBI, its subsidiaries joined as independent companies.

Croon started as a small family company, over 70 years growing into the utility and marine markets. As the company grew after World War Two the share of marine work decreases whilst that of utility and industrial construction increased. Presently 50% of revenue is obtained from utility building construction and maintenance, 20% from infrastructure projects, 15% from heavy industry, 11% from marine and 4% from other ventures.

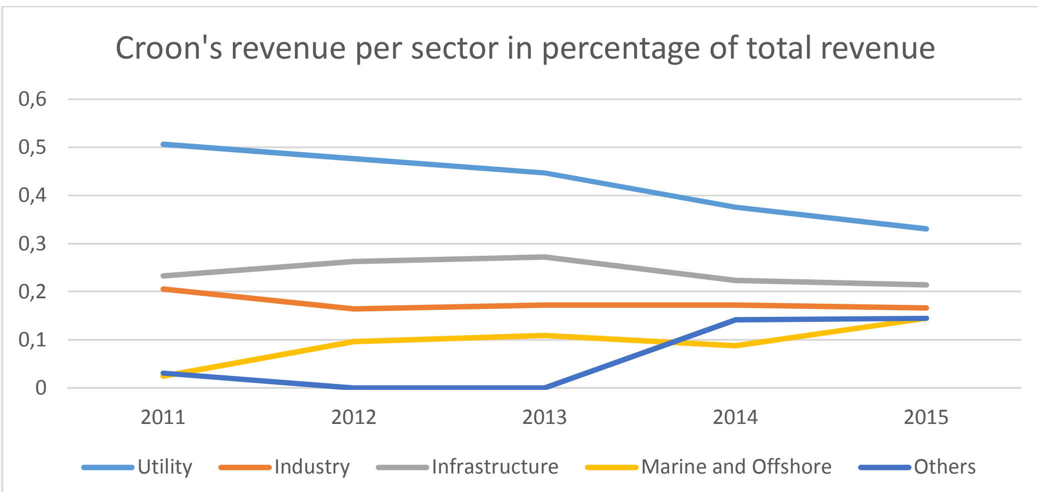


Figure 2.3: Croon's revenue per sector from 2011-2015.

2.1.1.4. Conclusion

From this short history it can be concluded Croon does not have a core business through its history. Rather it provides installation and integration of numerous systems - first telegraph, then phone and electricity - to a wide range of consumers, ranging from individuals, to factories, to the Dutch Navy and Crown.

The strength of Croon is not one rigid product group or service. Rather Croon is an opportunistic company providing installation services for nearly all electrical installation services the market demands. Croon does not push the newest technologies, it installs new technologies after a client asks for them. Currently this means Croon behaves as a systems integrator with a focus on utility building.

2.1.2. Bid / no bid

One of the most crucial decisions for a company is to bid or not to bid when an invitation to tender has been received. The decision to bid not only includes the probability of winning but also takes into account the ability to finish the job as planned with expected profit (Egemen & Mohamed, 2007).

The following section explores bid / no bid models in the literature, after which the process employed by Croon and the bid / no bid forms it uses are examined.

2.1.2.1. What is the bid / no bid decision?

A great deal has already been written on (pre)selection of contractors(Boer, Linthorst, Schotanus, & Telgen, 2006; Watt, Kayis, & Willey, 2010), creating evaluation models and criteria (Mateus, Ferreira, & Carreira, 2010; Tsai, Wang, & Lin, 2007), some of it even standardized(European Commission, 2013). Most of this literature has the interests of procurers in mind; according to Shash (1993) little literature reviews the rationale of bid / no bid decisions by contractors.

The bid / no bid decision is part of the bidding process employed by contractors. According to Jarkas, Mubarak, and Kadri (2013) considerable effort has been put into developing models and identifying bidding strategies employed by contractors, but little use has been made of the models. This is caused by the characteristics of the bidding process, which is 'largely dependent upon contractor's emotional responses, intuition and previous experience, rather than mathematical formulas and equations.' It is a 'spur of the moment' decision, undertaken without elaboration or deep reasoning.

To increase the use of models researchers have identified and ranked factors by their perceived importance to contractors.

2.1.2.2. Bid / no bid process at Croon

Making a bid / no bid decision is officially required at all TBI companies above a certain threshold. This threshold is different per company and set at € 15.000.000 at Croon. Below this threshold it is not required to follow the bid / no bid process, but it is recommended.

This decision is undertaken by different functions in the organization based on, contract value, location, contract type and type of cooperation. This can be found in figure 2.4. The bid / no bid process is started by entering a request for a bid / no bid decision in an online tool, where it is evaluated by the automatically assigned 'right' person based on information entered. This person then undertakes a non-formalized bid / no bid decision resulting in the (dis)continuation of the tender at Croon(Croon, 2016).

For integrated projects a different process is advised. Projects of interest, either because of high value or other complexities, use a tender board. The tender board uses the following standardized bid / no bid process.

First a preselection is made by the tender board, after which these projects are assigned a tender manager. Under the direction of the tender manager the project is elaborated. At a non-specified point a go / no go decision is made based on a checklist (appendix B.1.).

Based on the information found on the Croon intranet, as well as conversations with Cornet (2016) it can be concluded the bid / no bid decision making process at Croon is presently largely unstructured. In the tendering process milestones have been set but no formalized tool is used to evaluate opportunities. Furthermore there is little to no documentation when the decision is made. Finally the content in the tender board checklist gives the appearance the list is used to make sure all topics are covered, rather than balancing advantages and disadvantages of a project.

Het bid besluit wordt genomen door:	Sales Manager	Manager Sales	BG Directeur	BG Directeur & Stat. Directeur
Bij een verkoopkans van				
Geschatte verkoopprijs	Minder dan € 1 MIO	Tussen € 1 MIO en € 2,5 MIO	Tussen € 2,5MIO en € 10MIO	Meer dan € 10 MIO
Voorziening	Minder dan € 250K	Minder dan € 250K	Minder dan € 250K	Meer dan € 250K of onbekend
Nationaal / Internationaal	Nationaal	Nationaal	Nationaal	Internationaal
Contractvorm	Traditioneel	Traditioneel	Traditioneel	Samenwerkingsconcepten
Samenwerkingsmodellen	Geen BV of VOF	Geen BV of VOF	Geen BV of VOF	BV of VOF
Rollen in de Businessgroups				
Building Technologies	Dolf de Leeuw (NO), Jeffrey Gadellaa (NW), Patrick Kennis (ZW), Paul Brok (ZO)	Leo Mensink	Kees Padmos	Kees Padmos & Lennart Koek
Industry	->	->	Siebe van Oosterbaan	Siebe van Oosterbaan & Lennart Koek
Marine & Offshore	Maurice Seijkens	Ad Davidse	Eric Backhuis	Eric Backhuis & Lennart Koek
Infra	->	->	Jan Willemsen	Jan Willemsen & Lennart Koek
Design Engineering	->	->	Sven Asijee	Sven Asijee & Lennart Koek
International	->	->	Aco van de Ven	Aco van de Ven & Lennart Koek

Figure 2.4: Croon's thresholds for decision making responsibilities

2.1.2.3. Bid / no bid forms

To get a first indication of what Croon finds important the bid / no bid forms it employs are compared to the questions Lewis (2002) proposes for bid / no bid decision making. The factors used to categorize are established in chapter two. The bid / no bid forms used by the divisions International Projects and Heavy Industries will be compared, after which a conclusion for Croon will be drawn.

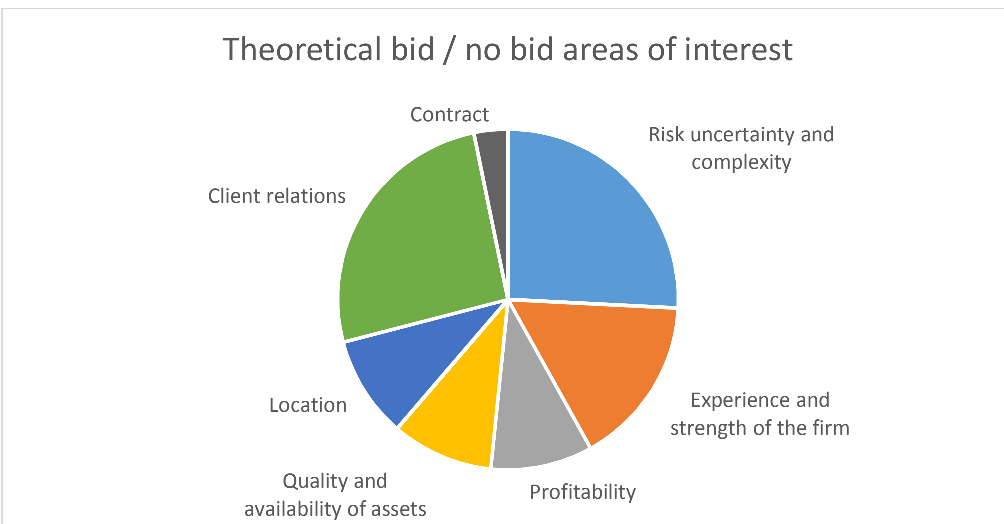


Figure 2.5: Bid / no bid question distribution in Lewis

International Projects is similar to the percentage of questions per topic only for Risk, Location, Contract and Job Size. Lewis places significantly more emphasis on Client relations and Experience than International Projects does; it places great emphasis on Profitability and Quality of assets which are of secondary importance to Lewis. Job type, Client Financial standing, or Client Identity are not mentioned by mentioned explicitly by Lewis.

The importance International Projects places on Job type, Client Financial and Client Identity can be traced back to the type of work and conditions in which the division operates. These questions are used by International Projects to thoroughly question the client related risks such as insolvency and payment conditions of a project.

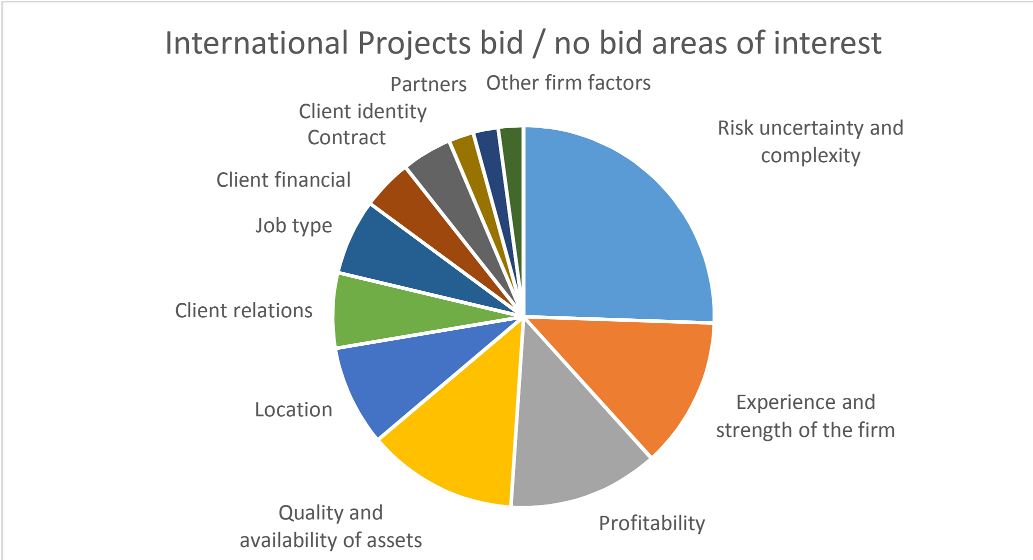


Figure 2.6: Bid / no bid question distribution at Croon International Projects division

The Heavy Industries division places the same emphasis on Risk as International Projects and Lewis do. For all other factors it is different though. Less emphasis is placed on Experience, and Profitability, and Location and Client Relations are not important at all. More emphasis is placed on Quality and availability of Assets and Contract. Lewis does not mention factors relating to Job Type, Client Financial, Client Identity and Job Size whilst these factors are moderately important for Heavy Industries.

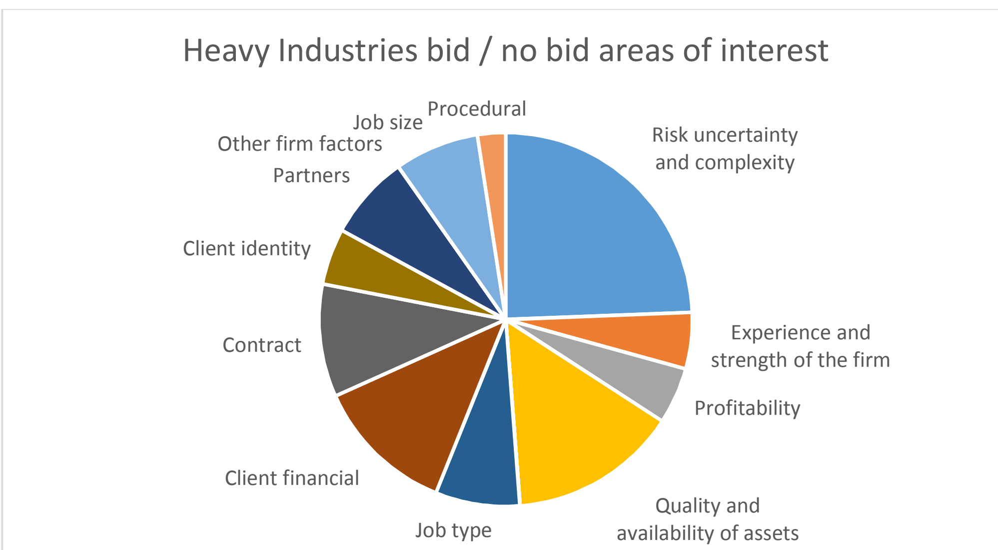


Figure 2.7: Bid / no bid question distribution at Croon Heavy Industries division.

2.1.2.4. Conclusion

Croon places large emphasis on Risk, Uncertainty and Complexity, with 25% of the questions being allocated to this category. This is in line with the questions proposed by Lewis. Quality and Availability of Assets is of second importance to Croon.

Finally Experience and Strength of the firm is of great importance to International Projects but receives little attention from Heavy Industries. On other topics both divisions are not in agreement on importance nor topics. Both have a large number of factors with only a few questions which corroborates the identifying function of the bid / no bid process at Croon. It appears the goal of the bid / no bid forms is not a deliberate consideration tool, rather it is a tool for documenting information.

2.2. Method Selection

The main objective of this research is developing a tool structuring the bid / no bid decision. A tool capable of systematically disseminating a project, transforming and presenting decision information is required. In the following section the sub question; *"What method is best suited for comparing and ranking projects?"* will be answered by establishing an ideal tool and comparing multiple types of methods and their associated methods for their applicability.

This ideal tool is introduced in order to determine the criteria for selecting a method. Then four types of models will be discussed, a model type is selected and finally a method from that type will be decided upon.

2.2.1. Ideal tool

The first step for selecting a method for future use is determining what the ideal tool looks like. This ideal tool will serve as the criteria for selecting the method to be used for structuring the bid / no bid decision for large infrastructure projects.

Firstly both quantitative and qualitative factors should be included. Based on the preliminary literature review it is expected both kinds of factors will need to be taken into account in the bid / no bid decision.

Furthermore the final decision should lie with decision makers. In an industry previously dependent on unstructured decision making imposing a tool with clear cut go / no-go decision making is not feasible. The tool should serve as a tool for decision makers to improve the reliability and replicability of their decision. Some space should be left to decision makers to allow for entrepreneurship or extraordinary times. A rigid tool, unable to incorporate these dynamics, is not desirable.

This means the tool must be transparent. For decision makers to accept it the method of generating weights and reaching decision should be evident.

Finally the tool should order alternatives based on prefer ability. Scoring on an abstract ranking introduces additional demands, such as setting decision making rules. Rather comparing with other (real) projects removes this complexity. Additional benefits are improving the familiarity of the tool and opening avenues for knowledge capture.

2.2.2. Decision making method types

Verhaeghe (2009, pp. 19, 20) states four basic types of methods are available when considering a decision problem. The method types will be shortly discussed below, and their applicability to bid / no bid decision making is considered. The selected type of method will be further elaborated, and a method will be selected.

2.2.2.1. Monetary evaluation methods

Firstly there are monetary evaluation methods; off which (socio-economic) cost-benefit analysis is the most well-known. In cost benefit analysis different options are valued in a common currency and discounted over their respective time horizons. The project with the highest net present value should be chosen (Verhaeghe, 2009, p. 20).

The downside of these methods is not all effects can be quantified in monetary terms. This is especially true for the bid / no bid decision, where the project itself might be quantifiable, the contractor side of the equation is largely intangible. The factor Quality of Assets for example is very hard to transform into a value.

Furthermore decision makers deal with incomplete information at the start of a project; it is not always known if more suitable projects will present themselves in the foreseeable future. Neither is the profitability of a project known. Because of these disadvantages monetary evaluation methods will not be used as the basis for the desired tool.

2.2.2.2. Overview table methods

A second type of model is the overview table; of which the balanced scorecard is the most well-known. Overview table methods are used for primarily qualitative decision problems where graphically accentuating the order of alternatives for each criteria informs decision makers (Ministerie van Financien, 1992).

The main advantage of the method is it allows for comparing all kinds of qualitative data on widely ranging scales. Furthermore data is not transformed, just presented in a structured manner, making the method very understandable.

A large disadvantage is that for problems with many criteria the scorecard becomes illegible and hard to understand. Secondly the scorecard does not allow weighting of criteria, nor does it make a statement about the order of alternatives under consideration. In the bid / no bid decision making, and thus the tool, a large number of factors need to be considered, which makes overview table methods an illogical choice.

2.2.2.3. Participation methods

The third type Verhaeghe (2009, p. 25)recognizes is participation models. In these methods costs and benefits should always be defined in relation to the realization of the goals of different predefined social groups. Participation methods seek to make the decision making process acceptable and reachable to a larger audience.

The major disadvantage according to Verhaege is the explicit distinction that needs to be made between different social groups. For this research participation methods are not applicable since different social groups do not have decision making power within a hierarchical firm. Furthermore the goals which form the basis for participation methods are hard to set, and can change from project to project needlessly increasing the complexity of the selected method. Because of these disadvantages participation methods will not be used for the decision making tool.

2.2.2.4. Multicriteria methods

Multicriteria type methods can accommodate a wide range of criteria on different scale types and allow preference information to be transformed into weighted criteria. These methods all have the same starting point; effects are summarized in an impact overview. If both quantitative and qualitative data is present the next step is usually standardizing data. Quantitative data does not necessarily have to be standardized, but it is possible.

According to Ministerie van Financien (1992) the determination of weights can be complicated and there are a plethora of methods to use, each with its own rules for determining the optimal solution. Because of its ability to use both quantitative and qualitative data, usage of weights and the possibility of a large number of criteria without becoming confusing a multicriteria method will be used in this research.

2.2.3. Multicriteria method selection

According to Dodgson, Spackman, Pearman, and Phillips (2009) multicriteria analysis methods are distinguished form each other in terms of how they process the information present in the impact overview.

The simplest model directly uses the performance matrix to check if one alternative clearly dominates all others. Slightly more complicated models allow alternatives to compensate a bad performance with a good performance. Models banning compensation are rare. The most used models all include compensation.

In the following section, based on Ministerie van Financien (1992), four methods will be discussed and compared, and one method for the tool will be selected. Compensatory models will be used for the tool; in the bid / no bid decision compensation is included.

2.2.3.1. Weighted sum

Weighted sum is the most straightforward multicriteria method; standardized criteria scores are multiplied by their respective weights. This process is repeated for every alternative and the highest total score is the most attractive alternative. This simple mechanism makes the weighted sum method very attractive for many decision problem. It is not applicable for the tool because it is solely usable on quantitative data.

2.2.3.2. Concordance

Concordance methods such as ELECTRE are at the core pairwise comparisons between alternatives on predetermined criteria. Depending on the method alternatives are either accepted or discarded, or ordered based on prefer ability. Scores are achieved by summation of weights in the pairwise comparison. A score is added to the sum only if alternative A_i scores higher than A_j in the comparison A_{ij}.

The downside is only quantitative criteriumscores are allowed. Because the tool should incorporate both quantitative and qualitative criteriumscores concordance methods are not suitable.

2.2.3.3. Evamix

The goal of the Evamix method is using as much of the available data as possible. This means taking into account both unstructured qualitative data, as well as qualitative data on ratio scales. Evamix uses pairwise comparisons to generate a concordance matrix within each data type to determine scores. Both types of data are treated separately until they summed up at the last stage, producing an order of the alternatives under consideration.

According to Ministerie van Financien (1992) a disadvantage of this method is the reliance of the total score on the comparison between more than two alternatives.

2.2.3.4. Permutation

The permutation method compares all possible orders of preferences for alternatives and compares them to the impact overview. If the preference order under investigation is the same as the order present in the impact overview a "+" is scored. If the order present is the opposite of the preference order a "–" is scored. All plusses and minuses are summed, and the order with the highest total score is the best order.

The downside of this method is it quickly becomes computationally complex as the number of alternatives increases; ½ n (n-1) pairs need to be considered. Furthermore valuable scale and distance information is lost in the process. The only information left is the ranking.

2.2.3.5. *Conclusion*

The multicriteria method Evamix was selected as the comparison tool to determine the attractiveness of a project. It is most applicable to this decision making problem because it can compare both quantitative and qualitative criteria and creates a ranking of projects whilst remaining relatively transparent to decision makers. Evamix will be used solely for comparing alternatives; standardizing the impact overview and generating weights will be done using other tools. These tools will be introduced in chapter five.

In table 2.1. the four discussed methods are summarized and their performance is displayed. Based on the four criteria for the ideal tool set in section 2.3.1.

	Quantitative and qualitative data	Dynamic tool	Transparent	Ordering of multiple alternatives	Sum
Weighted sum	-	0	0	-	--
Concordance	-	0	0	-	--
Evamix	+	0	0	+	++
Permutation	+	0	-	+	+

Table 2.1: Appraisal of multi criteria methods.

3. Factor identification and cross check

In this chapter the foundation for building the Bid / no bid tool is lain by identifying factors important to the bid / no bid decision and competitiveness. Where chapter two focussed on the process at Croon and literature of bid / no bid decision making and competitiveness this chapter deals solely with the factors identified by both literary fields to answer the following sub questions:

- *What factors critical to bid / no bid decision making and competitiveness can be derived from theory?*

In the first section of this chapter competitiveness is examined. The factors which influence competitiveness for projects are derived from literature using three methods; network analysis, cluster analysis and the APP framework.

The second section focusses on bid / no bid and the factors associated with making the decision. The bid / no bid literature is more centralized and homogeneous than that of competitiveness, therefore network analysis immediately leads to satisfactory results.

Finally, section three describes similar factors found both in competitiveness and bid / no bid. These factors are combined to decreases the total number of factors which need to be considered in chapter four.

This methodology is graphically represented in figure 3.2., and also includes the number of factors per stage.

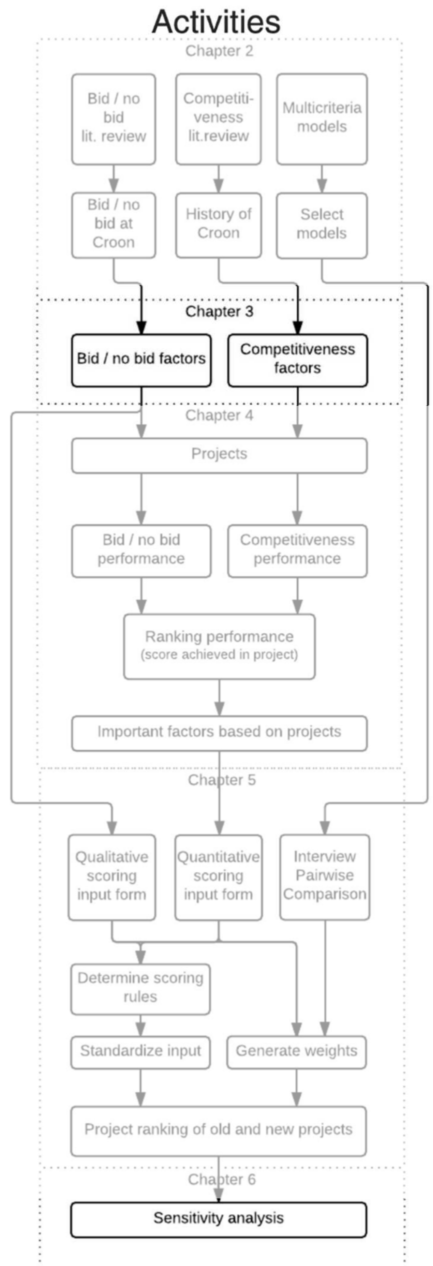


Figure 3.1: Position of chapter three in the research methodology.

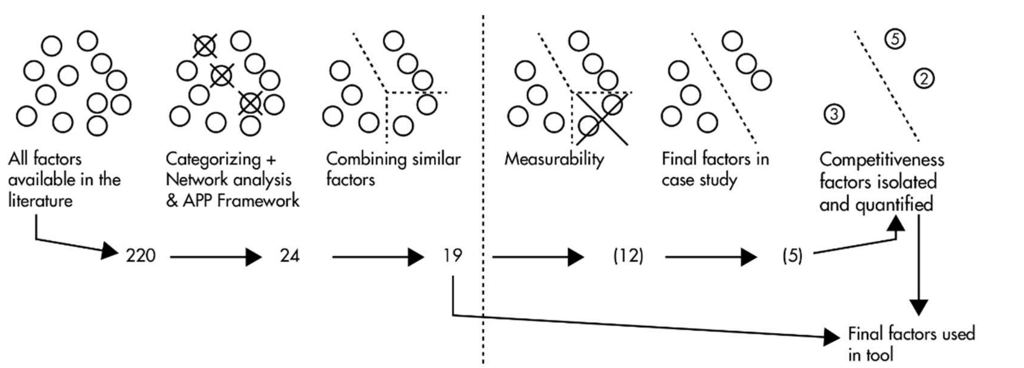


Figure 3.1: Factor selection methodology and resulting number of factors sourced from both bid / no bid and competitiveness

3.1. Competitiveness factor identification

In this chapter competitiviensss factors are extruded from literature using three methods, resulting in ten distinct factors. As described in 2.1.1.1. competitiveness can be understood on multiple levels. Only project and product factors are considered in this research.

To identify the competitiveness factors applicable to the project level the following section uses network analysis and the APP framework. This results in ten factors which make up project competitiveness.

3.1.1. Network analysis

The first step for selecting factors is identifying the most central authors in the construction competitiveness literary field. Based on network analysis it can be concluded small clusters of research built on the pioneering research by Drew and Skitmore (1997; 2001; 1992) each have a different purpose and find their own factors. A larger size network graph for competitiveness as well as the centrality scores of the 'top' authors can be found in Appendix C.1. and C.2.

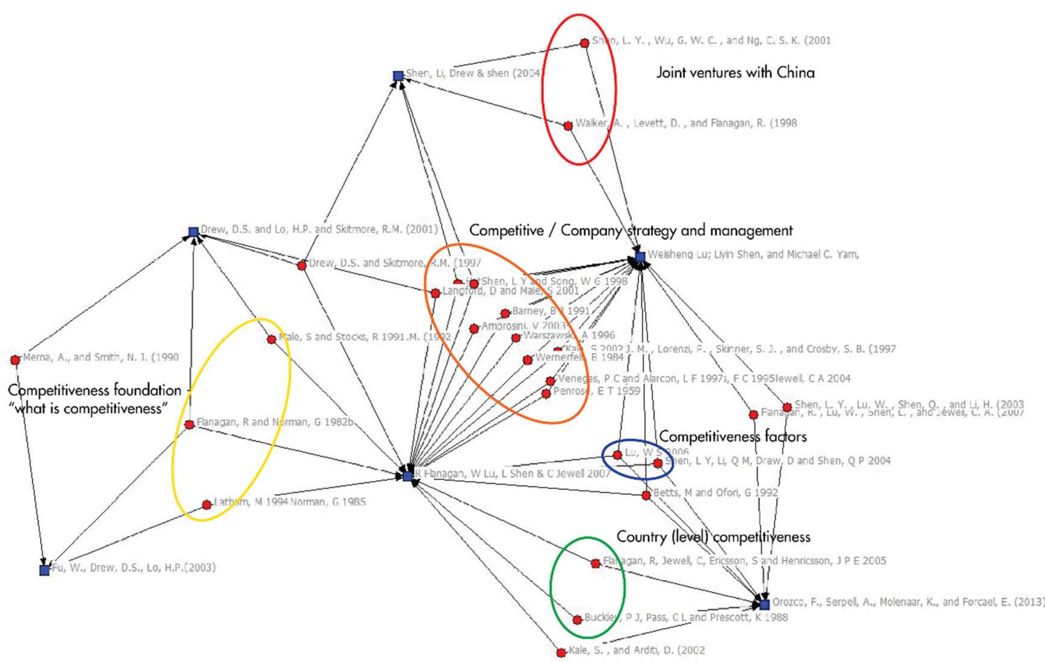


Figure 3.2: Competitiveness literature network, including identification of clusters. Source: Own illustration.

3.1.2. APP Framework

To circumvent this problem and narrow down the range of factors the APP framework by Ajitabh and Momaya (2004) has been used. It determines competitiveness for businesses as:

$$Asset\ x\ Process\ =\ Performance \tag{1}$$

Where Assets are inherited (natural resources) or created (infrastructure) and processes transform assets to achieve economic gains from sales to customers. Competitiveness is usually seen as (competitive) performance.

Performance is not seen as an independent variable, but rather as a function of assets and processes. The goal of this chapter is to find tangible factors which influence competitive performance. Process factor are not taken into account, they include factor such as:

- Strategic management;
- Formal planning;
- Financial stability of the firm;
- Government incentives.

This model provides a usable framework for separating factors to only include project factors as well as a corroboration of the disunion of process and project factors.

3.1.3. Asset factor assignment method

The first step for categorizing factors was by assigning similar factors into clusters as defined by Lu (2006). A summary of these categories can be found in Appendix C.7. Other categories, such as the set defined by Lu et al. (2008) can also be used but the selected set is the most inclusive on both the project and firm level. Many other authors focus on the industry or country level, which makes their research too general for this application.

The second step is combining similar factors within the categories proposed by Lu to create factors that reflect the complete literature. The literature contains about 40 unique factors, which can be combined into 10 based on their great similarity as can be seen in Appendix C.7. Because authors do not reference each other (often) the factors identified by one receive a different name in another study.

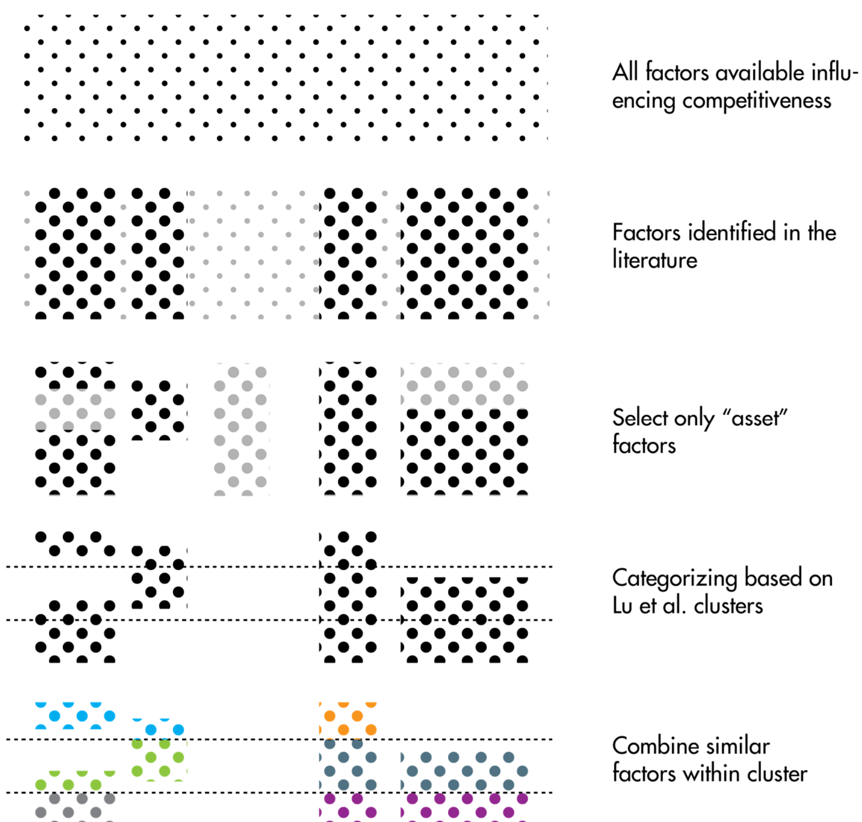


Figure 3.3: Competitiveness factor identification process. Source: Own illustration.

The following factors for project competitiveness have been identified:

Category	Factor	Description
Technical ability	Innovations	Innovations create diversification and enables a contractor to distinguish itself.
	Specialization	Specialization determines the ability of a contractor to successfully complete a project.
Organization structure	Need for work	Need for work determines the incentive contractors have to decrease prices to pay their workforce.
Marketing ability	Local market conditions	Local market conditions determines the attractiveness of the market and expected profitability of a contractor.
	Partners	The identity of a partner determines the presence of synergy and fraternity which might lead to creation of higher quality products.
Social influence	Client	Client type determines the diversity of projects and their procedure.
	Experience	Experience decreases risks premium and increases construction cost economy.
	Contract type	Contract type determines the type of work included in a contract
	Contract size	Contract size determines the (financial) assets required.
Contribution to project	Complexity	Increased complexity decreases transparency of a project, requires a greater expense of planning and experienced managers, greatly affects time, cost and quality.

Table 3.2: Identified project competitiveness factors.

3.2. **Bid / no bid Factor identification**

The bid / no bid literature that is available all follows the same pattern; a survey is sent to selected contractors and the factors these contractors find most important are extracted for further use. This has resulted in over 80 factors which have some importance. Cheng et al.(2011) performed a meta-analysis of the literature and found sixteen factors, grouped in ten categories to be present in most studies. The factors identified by Cheng et al. are too broad for practical use however. They aid in developing an understanding of the bid / no bid decision, but are not measureable.

Measurable, comprehensive and significant factors have been found by Jarkas et al. (2013) when investigating critical factors determining the bid / no bid decision of contractors in Qatar. They have identified five classifications, containing 28 critical factors for civil engineering contracts. A cross section of the literature is needed however, and two papers cannot achieve that goal.

3.2.1.1. Bid / no bid network

Network analysis of the field can fill this gap. 'Global centrality', is an often used measurement to determine the focal point of the network (Scott, 2000, p. 82). A measurement which combines the concept of global centrality with the prominence of a local group in the network is *eigenvector centrality*. Bonacich (2007) describes eigenvector centrality as more robust, as it is usable in a wider range of networks than other measures of centrality such as degree. This robustness makes eigenvector centrality the best choice for measuring centrality in networks where a few nodes have a large number of connections. Particularly for networks where a core-periphery structure is not clearly defined eigenvector centrality can provide robust results.

A limit of eigenvector centrality > 0.2 was used to identify the most central authors. Their names and the topic they research can be found in Appendix C.4. Not all authors developed or used factors in their research. Therefore not every author described in Appendix C.4. can be used. Friedman for developed one of the first models that describes bidding behaviour and is therefore often cited by other authors, but he does not list any tangible factors.

3.2.1.2. Identification process

The number of factors identified by each author, as well as the centrality score the respective paper achieved can be seen in Appendix C.4. and C.5. A complete lists of factors identified by each author can be found in Appendix C.5. the graph depicting the entire bid / no bid literature network can be found in Appendix C.2.

Based on the most central authors fourteen factors and four categories can be distinguished. These factors have been identified by starting with the factors from Ahmad and Minkarah (1988) and adding unique factors identified by other authors. Appendix C.6. shows these additions per author. These factors were then clustered into categories based similar overarching themes such as project / firm or market influences. Based on multiple researches in the field, factors can be categorized in atleast four themes; project / firm / market and client.

The categories and their respective factors can be seen in table 3.2.

Category	Factor	Description
Project	Job Type and size	Job type determines the sector within which the project is located. Job size determines the complexity and (financial) assets required.
	Profitability	Higher profitability makes a project more attractive to bid upon; for similar investments a higher return on capital can be achieved.
	Risks, Uncertainty & Complexity	Risk affects the outcome and performance of a project and is a contributor to complexity
	Location	Location influences the amount of knowledge about costs, economic conditions, partners and competitors which is available.
	Design & Document quality	Design and document quality decreases the disruptions to work progress decreases project costs
	Contract	Contract conditions define the type(s) of skills a project requires.
Firm	Experience and strength of the firm	Strength is built by gaining experience is specific tasks and is comprised of capital, knowledge, skill or other advantages the firm has over competitors.
	Quality and availability of assets	Quality and availability of assets, both man and machine, directly influences workload and expected quality of the product.
	Workload	Workload is used to buffer demand uncertainty in the market.
Market	Economic conditions	Economic conditions determine the total number of project available to the (domestic) market.
	Competition	Competition influences the probability of winning a project.
Client	Identity and type	Type of client influences the characteristics of the project and the contract.
	Relations	Client relations provide information and knowledge about demands and reliability of the client.
	Financial	Client finances provide information about reliability of timely payment.

Table 3.3: Identified bid / no bid factors.

3.3. Similar factors

Similar factors present in both competitiveness and bid / no bid need to be identified to increase independence of factors and to decrease the number of factors which need to be considered in subsequent chapters.

Out of the 26 factors identified 6 show high similarity. Similar factors and a definition which includes all similar factors have been combined in the section.

3.3.1.1. Need for work & Workload

Need for work is defined in competitiveness literature as an incentive for contractors to decrease their prices, to ensure workforce and fixed costs are covered. In Bid / no bid literature a theoretical approach is found, which determines workload and need for work are used to buffer demand uncertainty in the market. Whilst both definitions are similar, the objective of buffering workload is hard to measure independent of need for work. The factors will be combined and used as a bid / no bid factor.

- *Workload is used to buffer demand uncertainty in the market and when low serves as an incentive to decrease prices to cover fixed costs.*

3.3.1.2. Client & Client identity and type

Client and the importance of client type is best defined in competitiveness literature; it is defined as influencing size and procedure of a project. In bid / no bid literature client is seen as a variable which only has an influence on other variables. The inherent quality of client type has not been studied, therefor Client will only be used as a Competitiveness factor.

- *Client type determines the diversity of projects and their procedure.*

3.3.1.3. Job type and Size & Contract type & Contract

Competitiveness defines contract type as the type of work included in a contract, whilst bid / no bid defines contract conditions as the type of skills a project requires. In practice both will measure the complexity and type of work included. Therefor the competitiveness definition will be used.

- *Contract conditions determines the type of work included in a contract.*

3.3.1.4. Local market conditions & Location

Local market conditions are determined by the location. Especially smaller contractors are more likely to have a city or area where they compete. These competitors change from location to location. Location is much broader than local market conditions, it includes both disagreeable factors such as travelling distance, as congenial factors such as knowledge of the local market. Location therefore has an influence on planning, scheduling and project control. Therefore location will be used.

- *Location influences planning, cost and other project controls.*

3.4. Effect on competitiveness

Some factors need to be excluded from comparison because they are very hard or impossible to forecast or measure. Finally some factors can be important for the bid / no bid decision but have no influence on competitiveness. These factors and the reason for exclusion are displayed in table 3.3.

Factor	**Excluded because**
Innovations	Not measurable at Croon
Specialization	Not measurable at Croon
Complexity	Not measurable / intangible
Profitability	Not forecastable
Design & Document quality	No influence on competitiveness
Client financial	No influence on competitiveness
Client relations	Insufficient data available at Croon

Table 3.4: Factors with no effect on competitiveness. These factors return in chapter five to enrich the bid / no bid decision making tool.

These factors will not be used for analysis in the case study projects, instead they will return in segment two – model design. Although the factors are not usable for determining the competitiveness of Croon, they are important for the bid / no bid decision as evidenced in this chapter. Eliminating them would impoverish the final bid / no bid model, making the final model needlessly simple and lacking in depth.

3.5. Conclusion

In this chapter the first goal; *Identifying key variables which influence a contractor's competitiveness and bid / no bid decision making,* has been completed by investigating two sub questions.

Firstly the question: *What criteria for project selection can be derived from theory on competitiveness and bid / no bid decision making?* was addressed.

Factors were derived from theory using network analysis and the APP framework. Network analysis provide the framework for selecting seven papers forming a comprehensive set of themes influencing competitiveness. Based on the APP framework and categories developed by Shen et al. these are combined into ten factors.

The selected factors from both literatures were compared for similarities to decrease the number of factors required to be investigated in chapter four. Seven similarities were found which can be combined into four new factors; workload, client identity, job type and size, and location.

Five more factors were excluded because they were not measurable, forecastable or had no influence on competitiveness. These factors will return in chapter five; although they do not have a direct influence on competitiveness they are still important to the bid / no bid decision. The factors in table 3.4. will be studied further using seven projects in chapter 3.

One unique factor to competitiveness was found; Partners are only important to this factor and are not or rarely mentioned in bid / no bid literature.

Factor	Description
Partners	The identity of a partner determines the presence of synergy and fraternity which might lead to creation of higher quality products.
Experience	Experience decreases risks premium and increases construction cost economy.
Contract size	Contract size determines the (financial) assets required.
Job Type and size	Job type determines the sector within which the project is located. Job size determines the complexity and (financial) assets required.
Risks, Uncertainty & Complexity	Risk affects the outcome and performance of a project and is a contributor to complexity
Experience and strength of the firm	Strength is built by gaining experience is specific tasks and is comprised of capital, knowledge, skill or other advantages the firm has over competitors.
Quality and availability of assets	Quality and availability of assets, both man and machine, directly influences workload and expected quality of the product.
Economic conditions	Economic conditions determine the total number of project available to the (domestic) market.
Competition	Competition influences the probability of winning a project.
Workload	Workload is used to buffer demand uncertainty in the market and when low serves as an incentive to decrease prices to cover fixed costs.
Client type	Client type determines the diversity of projects and their procedure.
Location	Location influences the amount of knowledge about costs, economic conditions, partners and competitors which is available.

Table 3.5: Identified and combined factors of possible influence on competitiveness.

4. Competitive influence of projects

In this chapter the factors found in chapter three are tested for their influence on the competitiveness for a project. The goal of this chapter is answering the following sub question to reduce the number of the number of factors that need to be compared and processed into the final tool.

- *Which identified criteria influence competitiveness on case study projects?*

This is the last chapter in segment one, after this chapter the most important factors to competiveness are known. The crucial factors will be quantified and used as a separate input for the tool, whilst the non-essential factors are combined with factors from chapter three for the qualitative part of the tool. Combined they provide an overview of the factors important to the bid / no bid decision.

Identifying influential criteria is done by performing a case study research on seven selected projects. Section 4.1 details the selection of these seven projects. Section 4.2 describes the projects and their characteristics. Section 4.3 forms the core of this chapter, in it, competitiveness and bid / no bid factors are analysed for their effect on Croon's competitiveness by combining performance with ranking.

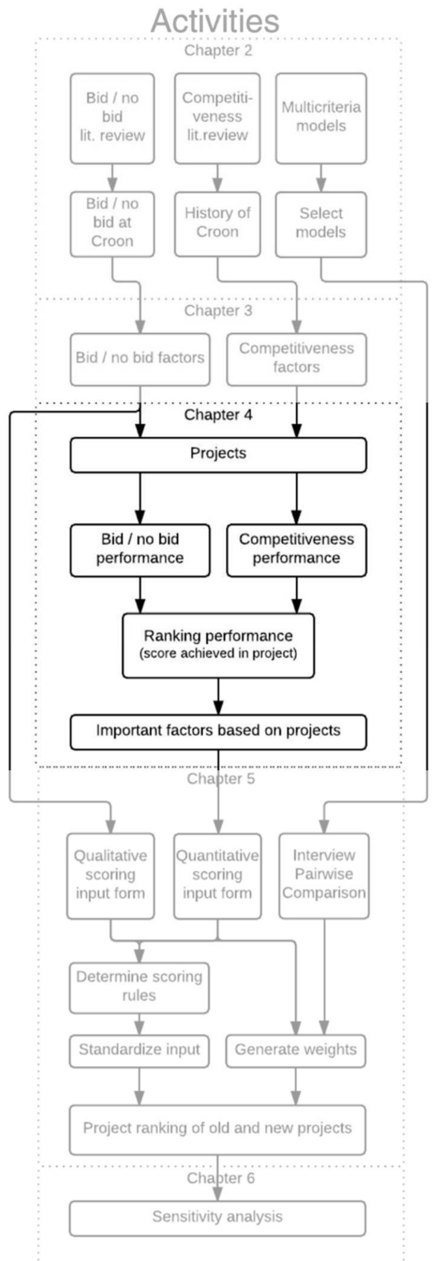


Figure 4.1: Position of chapter four in the research methodology.

4.1. Case study selection & description

A case study will be used in this research to determine the influence of selected bid / no bid and competitiveness factors on competitiveness. This section describes the selection method and selection of viable case study project, as well as a description of those projects.

4.1.1. Criteria

As stated in the demarcation chapter, all projects should be **integrated infrastructure EMAT** projects. These are complex projects which require knowledge of contract forms and different stages of the construction process. EMAT and infrastructure are selected as criteria because these projects are more complex and assessing (based on gut feeling) requires comparison of a large number of factors. Doing this successfully is more challenging than doing the same task for less complex projects.

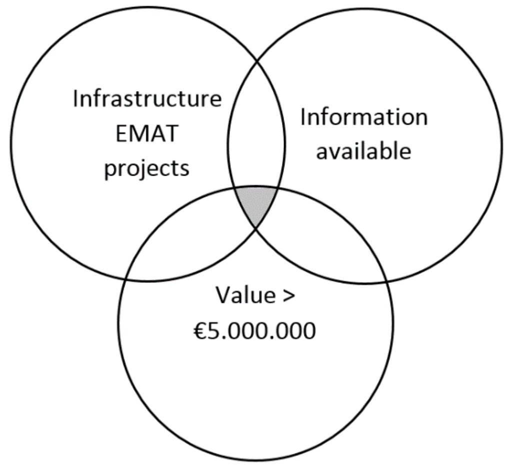


Figure 4.2: Case study selection criteria.

Secondly contracts should have a value of **€5.000.000 or more**. This ensures EMAT projects are chosen and increases the relevance of the research, as more costs are incurred on larger tenders.

Finally information about the projects must be readily available. Complete knowledge of the competitors, price level and contents of the project is required to accurately compare them. This requires the project to have started after 2011 and procurement to be finished. Furthermore Croon must have participated and thus obtained data, and the project should be in the Netherlands to ensure Croon has knowledge of the market.

4.1.2. Project Selection

Based on the criteria established in the previous section table 4.1. displays 12 prospect projects. Out of these twelve two were discarded because their contract value was too low. Another was discarded because it was not an integrated contract, finally another two were discarded because Croon did not participate in the tenders.

The remaining seven projects will be further discussed in section 4.2.

Project name	Contract value	EMAT project	Integrated contract	Information available	Selected
Betuweroute asset management	23.000.000	Y	Y	Y	Y
CBI Metro Amsterdam	20.000.000	Y	Y	Y	Y
Construction Ring Zuid Groningen	45.000.000	Y	Y	N	N
Construction Rotterdamsebaan	300.000.000	Y	Y	Y	Y
Hoeksche Lijn Construction	72.000.000	Y	N	Y	N
Maintenance IJsselmeergebied	42.000.000	Y	Y	Y	Y
North Holland maintenance and incident management	3.500.000	Y	N	N	N
Pumps Albertkanaal	9.500.000	Y	Y	N	N
Renovation Maastunnel	65.000.000	Y	Y	Y	Y
SAA3 Gaasperdammerweg	480.000.000	Y	Y	Y	Y
VIT 2 IA Tunnel information systems	4.800.000	Y	Y	N	N
VIT 2 TTI Tunnel upgrading	33.000.000	Y	Y	Y	Y

Table 4.6: Project selection based on the determined criteria results in seven case study projects.

4.2. **Project description & typology**

In order to determine the influence of competitiveness factors on tendering success projects are needed to measure this influence. In this section a short background to each project is provided.

The second part of this section typifies both won and lost projects using the Kraljic matrix. The Kraljic matrix is an often used method for determining the role of an item or project in a portfolio.

4.2.1. Project description

In this section the selected case study based on section 4.1.2. are described. First the three won projects – VIT 2 TTI, Maastunnel and IJsselmeergebied – are described. The remaining four projects –Rotterdamsebaan, Metro Amsterdam, Gaasperdammerweg and Betuweroute – were all lost.

4.2.1.1. VIT2 TTI

The VIT2 TTI project contains the demolition of old Tunnel Installations and construction of new Tunnel Installations in ten tunnels in the provinces of North- and South Holland. The €33 million price-corrected contract was won by a consortium of Croon and Siemens based on quality. The project includes the design and construction of tunnel installations, as well as demolition of old installations and organisation of road closure.

Figure 4.3: Tunnel entrances of the tunnels included in VIT 2 TTI. From top to bottom: Drechttunnel, Schipholtunnel,

4.2.1.1. Maastunnel

The Maastunnel is the oldest submerged tunnel in the Netherlands, located in the municipality of Rotterdam. Because of its age, and the new Tunnel standard, it needs to be renewed. The tunnel does not use conventional 'modern' installations, rather all installations are included in the tunnel construction.

The contract requires the complete demolition of existing roads and it's substructure as well as tunnel installations. Great care needs to be taken for safety because asbestos is most likely present in large amounts.

Further increasing complexity is the Rijksmonument status of the Maastunnel, which makes interventions more complicated as a lengthier procedure is required. Finally the Maastunnel is a crucial crossing for the road network in Rotterdam and the municipality has placed great emphasis on the minimization of closure and planning of activities.

Half of the EMAT score obtainable can be achieved for planning. Croon, together with TBI partners Wolter & Dros and Mobilis won the €65 million contract based primarily on lowest price in a price-corrected scoring tender.

Figure 4.4: The northern entrance to the Maastunnel.
Source: http://www.rijnmond.nl/nieuws/136634/Maastunnel-3-maanden-s-avonds-en-in-weekeinden-dicht

4.2.1.2. Ijsselmeergebied

In this project maintenance and upgrading of bridges and sluices in the area surrounding the Ijsselmeer is outsourced by Rijkswaterstaat. The client is using this contract to obtain knowledge and experience with performance driven and preventive maintenance on seven objects. The contractor is required to create and utilize this performance driven model, which includes determining critical assets, FMECA, preventive and corrective maintenance leading to improvement proposals.

The total contract value is €42 million and uses price-corrected scoring. Croon won this contract together with Arcadis based primarily on lowest price. The contract is a performance contract, where Croon is responsible for maintaining and repairing civil engineering objects, electro technical and mechanical installations as well as designing and carrying out improvements to the existing infrastructure.

The monitoring and managing of a *performance* based contract as well as the diversity of objects are the main causes of complexity.

Figure 4.5: An overview of some of the civil engineering works included in the IJsselmeergebied contract. From top to bottom: Krabbersgat Naviduct, IJsseloog, Stevinsluices. From: https://commons.wikimedia.org/w/index.php?curid=27336606, https://i.imgur.com/PAMSSLF.jpg http://www.fotoclubdiafragma.nl/wp/2014/10/

4.2.1.3. Rotterdamsebaan

The Rotterdamsebaan is a Design Build and Maintain boring tunnel which connects the local road network to the A13 highway aiming to relieve the congested Utrechtsebaan. The project is jointly financed by the Municipality of The Hague and the Dutch Government and was first conceived in the 1950's.

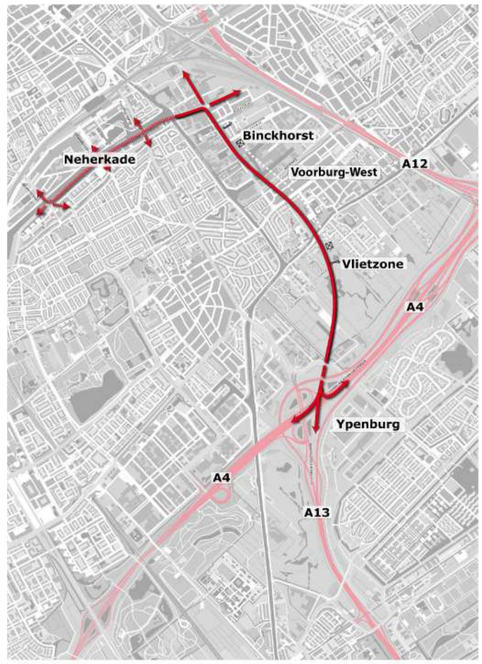


Figure 4.6: The proposed route and connections to the urban fabric for the Rotterdamsebaan.

The project is located in a dense urban network with numerous stakeholders, and consist of a boring tunnel, the construction of two open tunnels, and the connection of the tunnels to the local street network. Finally maintenance of the tunnel and other assets for 15 year is included. The duration of preparation, execution and maintenance due to complexity is expected to be long, leading to long term obligations and relations between the contractor and client.

Complexity is increased by the emphasis the municipality has placed on environmental management; 30% of EMAT score can be obtained for producing low hindrance and sound- and particulate emissions.

Croon, in a consortium with Mobilis, CFE and VINCI obtained the second rank in the €300m project, which was lost because of a lower EMAT score and nearly identical price as the top competitor. The project contained a total of €75 million EMAT score possible, with most of the quality assigned to risk management, environment management and sustainability.

Figure 4.7: Illustrator for the winning proposal by Saturn XIV.

4.2.1.1. CBI Metro Amsterdam

The CBI Metro Amsterdam contract contains the works necessary to realize a new central control system for the Amsterdam underground, containing both the existing network as well as the Noord-Zuidlijn. It primarily contains ICT work, backup systems, training of staff and maintenance including the 'Amstelveenlijn', a number of objects on different tramlines and traffic management, communication and operation. Croon was responsible for maintenance of the existing systems for 17 years.

The Amsterdam municipality has reviewed its standing on what is included in its definition of metro, it now includes six lines most of which are above ground. The contract should lead to a uniform operation of the power supply, station and tunnel installations.

Emphasis is placed on finishing on time, which directly influences two out of three EMAT criteria. This tender uses price-corrected scoring and has a value of €20 million. Croon obtained the *second* rank in this project based on a high price and high quality.

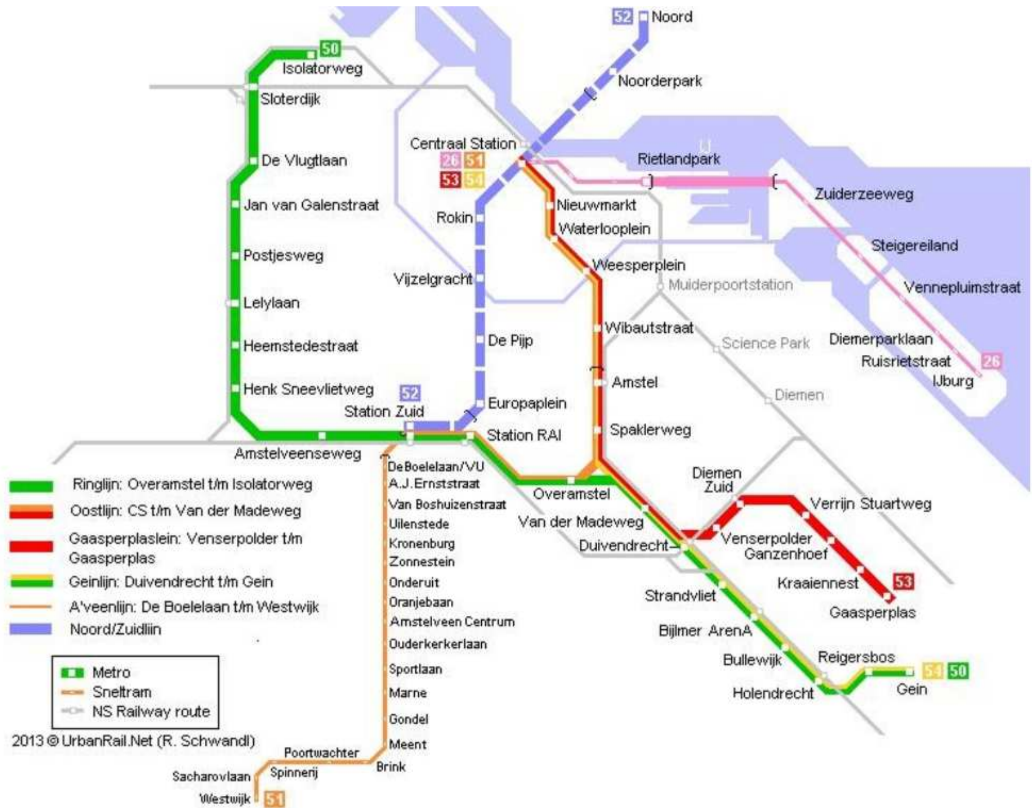


Figure 4.8: Stops and routes in the Amsterdam metro.

4.2.1.1. SAA3 Gaasperdammerweg

The Gaasperdammerweg project is one of several being undertaken by the Dutch Government to increase the capacity of the roads between Schiphol, Amsterdam and Almere. This project contains the creation of the largest landtunnel in Europe on the A9 highway. The projects foresees the construction of an 11-lane tunnel with a roof park on top and has a value of €480 million with DBFM conditions using price-corrected scoring.

To ensure continued availability of the highway a temporary road needs to be constructed and sophisticated phasing of activities is required to reach the 2020 opening deadline. Because the highway is located in a dense urban fabric great emphasis is place on reducing environmental nuisance. Croon, participating in a consortium together with other TBI partners and BAM obtained the third rank out of three competitors. The number one competitor won the contract on lowest price, and a nearly perfect EMAT score.

Figure 4.9: Gaasperdammerweg in the urban fabric, showing requirements set by Rijkswaterstaat.

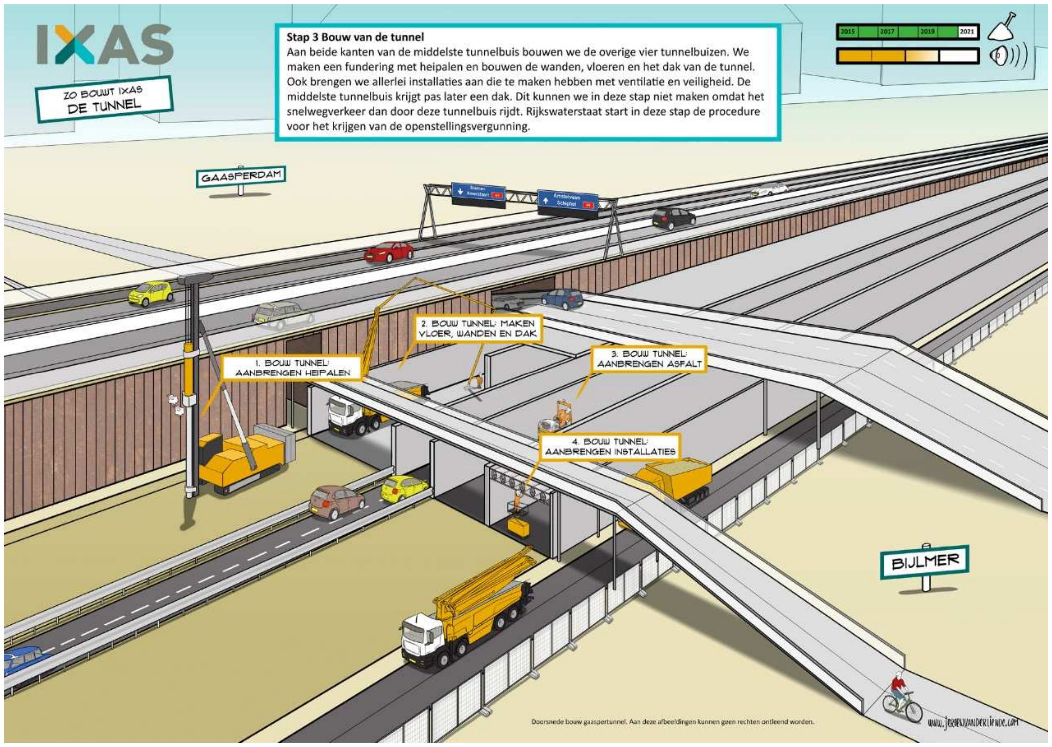


Figure 4.10: The winning competitors' (IXAS) proposed plan.

4.2.1.2. MA TTI Betuweroute

This contract contains the maintenance and Asset Management on a *performance* based contract, for five rail tunnels in the Betuweroute for KeyRail. An important characteristic of this contract is the contractor should guarantee availability of the tunnel for a specified amount of time where the contractor is responsible for planning, carrying out maintenance and inspecting Tunnel Technical Installations to ensure availability. The special scoring system used increases the complexity of the tender.

Rather than absolute scoring on a point based system the performance of each contractor is compared to the best score of competitors on either price or quality, resulting in a *relative* best contractor. Croon obtained the *fifth* rank in this project, based on a very high price and rather low quality. This tender uses value/price rated scoring and has a value of €23 million.

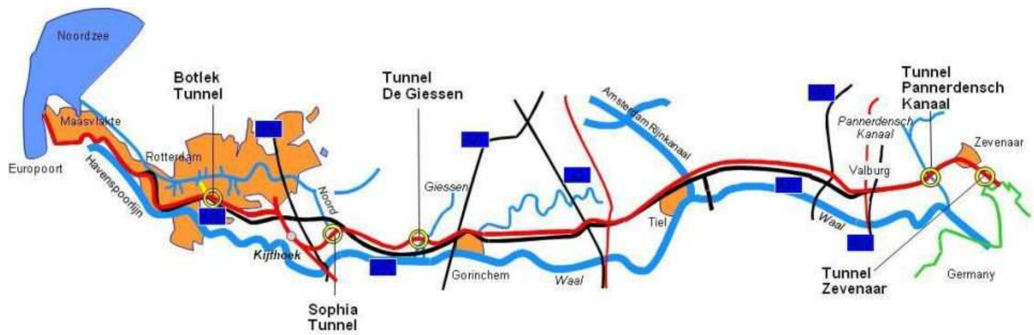


Figure 4.11: Betuweroute route through the southern Netherlands.

4.2.2. Types of projects

Not every project is the same, this is what makes them a project and not part of a process. This implies a unique distribution of for example risk for every project. Even though every project is unique, projects can be grouped into types. When combined with tendering results this can be used as a first insight into the competitive performance of Croon on each type of project.

The Kraljic framework presents fours sectors for typifying contracts, each representing a distinct distribution of power between client and contractor (Kraljic, 1983). According to Hombergen (2016) this notion can be expanded to construction contracts. Each sector thus represents a degree of complexity, collaboration and form of contract. The Kraljic framework for construction is displayed in figure 4.12. below.

According to Hombergen the axis of the matrix can be interpreted as the importance of the project to the client for the vertical axis, and as degree of difficulty to suppliers (with implications on number of suppliers) for the horizontal axis.

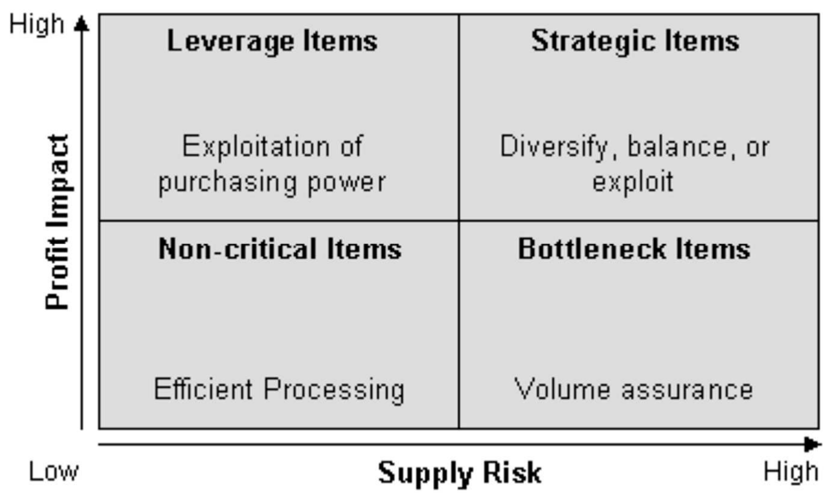


Figure 4.12: The Kraljic matrix showing four types of items. Source: http://www.proficientsourcing.com/tool-maximized-supply-security-reduced-costs-useful/

According to the Kraljic matrix the four following types of project exist;

- Non-critical or **Routine** items have low risk and are inexpensive items lasting less than 12 months. Examples are resurfacing of highways or constructing row housing. These projects are routine jobs for both the contractor and the client.
- **Bottleneck items** are innovative projects, risky but not necessarily very expensive, of differing time horizons. Examples are the train safety installations in the Delft Railtunnel or zero emissions housing. Bottleneck items are relative simple for the client, but of more importance to a contractor. Fewer competitors will be able to create these kinds of products.
- **Leverage items** are technologically not that risk, but very expensive projects. These types of projects are a lot of work, but have no risk and generally last between 12 and 24 months. Examples are tunnel construction on the Delft Railtunnel or large utility building construction such as hospitals. Leverage projects have a large (financial) impact on the client whilst simultaneously technology is not very complicated. A large number of contractors will be available for these types of jobs.

- **Strategic items** are high risk projects where the focus lies on making it happen. Contractors and the client share the risk and make a large effort to be create the best team in a long-term effort. Can lead to development of long-term supply relationships. Examples of this kind of projects are the Noord-Zuidlijn in Amsterdam or the Proton Treatment Center in Delft. These projects are of the highest importance to both the contractor and the client; reputation and credibility is at stake for both parties.

4.2.2.1. Case study project types

Determining the types of case study project can be divided into two problems; determining degree of difficulty of the project, and importance to the client. By classifying difficulty and importance from low to high a rough positioning within the matrix can be obtained. In the tables below an explanation for the degree of difficulty and importance to the client is coupled to supply and profit impact.

Project	Degree of difficulty to Croon	Supply risk
MA TTI Betuweroute	Never worked on large rail before	High
CBI Metro Amsterdam	Control rooms and ICT is not new	Med /low
Gaasperdammerweg	Large effort to design & build, years of work and experience to employees.	High
IJsselmeergebied	Increasing experise in wet infrastructure, otherwise routine work	Med /low
Maastunnel	Highly visible, complex, monumental inner city project under time pressure.	Med /high
Rotterdamsebaan	Large effort to design & build, years of work and experience to employees.	High
VIT 2 TTI	Little additional responsibilities, just build and install TTI	Med /low

Table 4.7: Supply risk of case study projects

Project	Importance to the client	Profit impact
MA TTI Betuweroute	No / little experience with tunnel maintenance, large amount of expertise with railway	Med/ high
CBI Metro Amsterdam	Good work is important, systems must work for long timespan. Otherwise not very special	Med / high
Gaasperdammerweg	One of the largest Rijkswaterstaat infrastructure projects of the decade, in a dense urban environment	Med / high
IJsselmeergebied	One of many area contracts. One of the first for Asset management and learning.	Low
Maastunnel	Monumental project increasing complexitity in a dense urban location. Contract size not very large for the client.	Med / low
Rotterdamsebaan	Politically very sensitive project, years in planning. Located in dense urban fabric.	Med / low
VIT 2 TTI	Many tunnels, availability must be maintained.	Med /low

Table 4.8: Profit impact of case study projects

Based on the method described three projects are of high difficulty to Croon. One is medium-high and three are medium-low. This implies the selected projects are predominantly of high difficulty, the largest minority is of medium-low difficulty. This shows a clear dichotomy in the types of projects selected.

Profit impact shows a distribution dissimilar to supply risk. There is one high risk project, four medium-high and two medium-low risk projects. The selected projects are almost all of high(er) impact to the client.

4.2.2.2. Conclusion

Figure 4.13. was generated based on the input obtained in table 4.7 and 4.8. It shows two Routine project; IJsselmeergebied and VIT 2 TTI. Both of these projects were successfully tendered. There is one Bottleneck project; Maastunnel, and only one Leverage; Amsterdam Metro. The three remaining projects are all Strategic items.

Based on the Kraljic matrix the won case study projects are all low profit impact, and tendering for critical project to clients appears to reduce Croon's competitiveness.

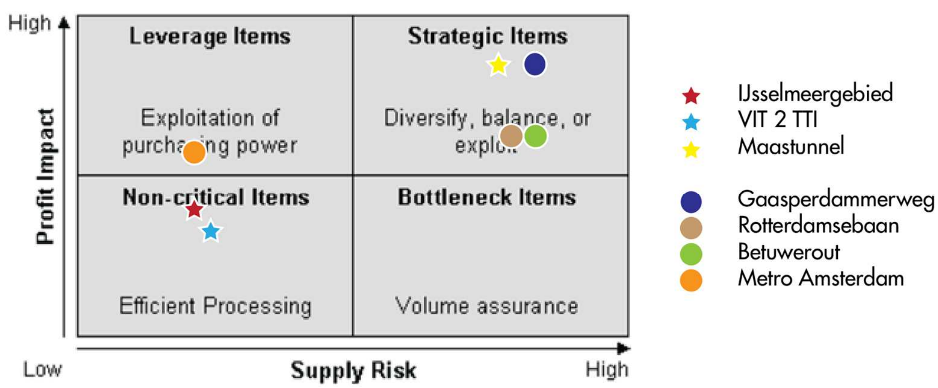


Figure 4.13: Position of the case study projects in the Kraljic matrix. Own illustration.

4.3. Competitiveness performance of projects

In this section the performance of Croon on seven projects is compared with performance on competitiveness and bid / no bid factors to estimate the influence of each factor on project performance.

First the framework under which this estimation is undertaken is described. This framework is implemented in section 4.3.2. and 4.3.3. on both competitiveness and bid / no bid factors. Each

4.3.1. Analysis framework

To determine the influence of competitiveness and bid / no bid factors on project performance each factor is analysed individually according to the following framework:

1. Establish performance measurement criteria
2. Measure performance of:
   a. Croon
   b. Best competitor
3. Compare performance of three won projects with four lost projects.
4. Aggregate multiple performance into total score.

This method compares the performance of won and lost tenders with Croon and the 'top' competitor – the highest scoring (not Croon) competitor for a specific tender. By using multiple measures and integrating them into one score a statement can be made about the influence of each factors on project performance.

A scorecard will be used to aggregate scores, this allows for unweighted summing of scores to determine the influence of every factor on competitiveness.

4.3.2. Project performance

The ranking used by the client is used as the determinant of project performance. The most commonly used multicriteria scoring method, taking into account cost and quality, for construction is the Economically Most Advantageous Tender (EMAT). This method ranks proposals using a unique procedure, which has been set in advance, for each project. It is argued EMAT is a better system for assessing the expected performance of a contractor(Dreschler, 2009). The EMAT procedure can be used as an indicator for the competitiveness of a contractor for a selected project.

Table 4.2. gives a short summary of the performance Croon delivered for each project.

Project	VIT 2 TTI	Renovatie Maastunnel	Ijsselmeer	Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Rank	1	1	1	2	2	3	5
Winning bid value	€ 32 M	€63 M	€ 43 M	€ 301 M	€ 17 M	€ 480 M	€ 24 M
Price corrected winning bid	€ 29 M	€ 60 M	€ 39 M	€ 254 M	€ 2 M	€ 268 M	€ 24 M
Competitor price corrected bids	€ 32 M € 35 M	€ 78 M	€ 44 M € 56 M € 60 M	€ 284 M € 309 M	€ 18 M	€ 300 M	€ 20 M € 24 M € 22 M
Croon-price corrected bid	€ 29 M	€ 60 M	€ 39 M	€ 262 M	€ 13 M	€ 340 M	€ 25 M

Table 4.9: Project performance on seven case study projects. Showing achieved rank and bid value for Croon and competitors.

4.3.3. Factor influence on competitiveness

In this section combined competitiveness and bid / no bid factors extracted from literature in chapter 3 are analysed according to the method described in section 4.3.1. Conclusions are presented in section 4.4.3.

4.3.3.1. Workload

Workload is assessed based on the metric developed by Tam and Harris (1996), which measures workload according to formula 2.

$$\frac{Total\ contract\ sum\ in\ hand}{Total\ no.of\ staff} \qquad (2)$$

The definition by Tam and Harris does not include a cut-off value for which workload is low or high. This is gauged by comparing workload to past performance of the firm. As can be seen in figure 4.14. average long-term workload in € per employee differs greatly from firm to firm. TBI and its subsidiaries have an exceptionally low workload. On the whole the industry is displaying a slight upward trend, Ballast Nedam is a notable exception with decreasing workload since 2010 and 2011 respectively. This can most likely be attributed to economic conditions in the Netherlands and is a cause for the reorientation Ballast Nedam is undertaking to become more competitive on complex projects.

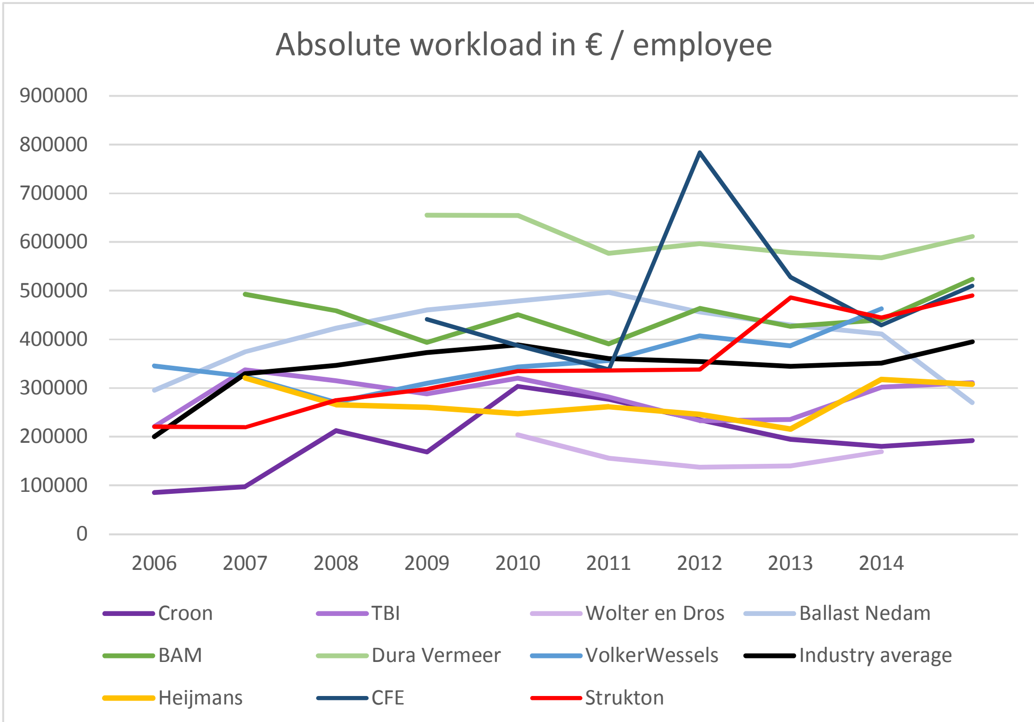


Figure 4.14: Absolute workload in the infrastructure market from 2006 – 2015. Source: own illustration based on published year reports.

To enable comparison relative workload of contractors is used. Relative workload is determined according to formula 3.

$$Relative\ workload = \frac{Workload\ year_x}{Average\ workload} \qquad (3)$$

		VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeergebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Year(s) of procurement		2014	2015	2012-2013	2014-2015	2013	2012-2014	2014-2015
Relative Workload at time of bidding	Lowest top competitor	0,937	Unknown	Unknown	**0,981**	Unknown	**0,795**	**0,981**
	Croon	0,925	0,988	1,203	0,925	0,997	1,204	0,925
Difference		+1,2%	N/A	N/A	+5.6%	N/A	-40.9%	+5.6%

Legend		
> 20% **POSITIVE** relative workload difference	Little workload difference	> 20% **NEGATIVE** relative workload difference

Table 4.10: Relative workload and difference in relative workload in the year of bidding.

The first test is comparing the workload in Croon and the top competitor during the procurement. The results are displayed in table 4.3. For the Maastunnel, IJsselmeergebied and CBI Amsterdam no workload figures could be determined because Dutch infrastructure is not the core business of the multinational competitor.

Of the seven contracts surveyed only one shows a large difference in relative workload; during bidding for the Gaasperdammerweg contract Heijmans had its lowest workload in available history, whilst Croon's was at a high point. The total difference in workload was 40.9%

For two other contracts, both awarded in 2015, there was a smaller difference in workload at 5.6%. Both the Rotterdamsebaan and Betuweroute contract were awarded to BAM. There is some evidence which supports large differences in workload lead to higher competitiveness.

The final test with regard to workload is checking the probability of deviation from average for the competing contractors assuming a normal distribution. Years in green show greatly above average workload, years in red show greatly below average workload. Years in yellow represent a won contract for that contractor. Bold percentages and workload show a competing contractor in that year.

Only one contract in 2012 has greatly below average workload and was won by that contractor. Other contracts show little correlation between degree of workload and the winning contractor. Two are won by contractors with below average workload, three are won by contractors with above average workload. There is little correlation between probability of deviation and winning or losing contracts.

Legend for table 4.11		
<20% probability of reaching workload this **HIGH** under assumption of average normal distribution	Contractor won a project in this year	<20% probability of reaching workload this **LOW** under assumption of average normal distribution

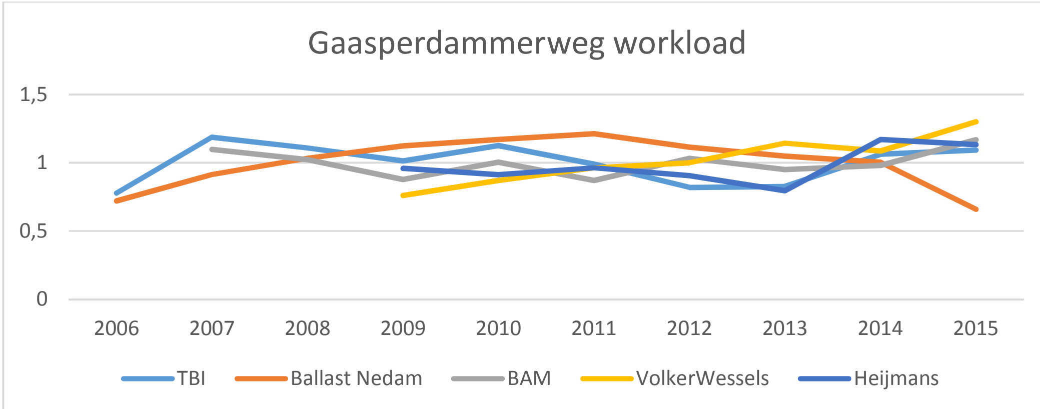


Figure 4.15: Workload of competitors at the Gaasperdammerweg contract.

	2010	2011	2012	2013	2014	2015	Standard deviation
Project procurements started in year (running years)			Ijsselmeergebied (2) Gaasperdammerweg (3)	Metro Amsterdam (1)	VIT 2 TTI (1) Rotterdamsebaan (2) Betuweroute MA TTI (2)	Maastunnel (1)	
TBI (probability of workload	1,12 (19%)	0,99 47%	**0,82 11%**	0,83 11%	**1,06 34%**	1,09 26%	0,14
Croon	1,56 6%	1,42 12%	1,21 28%	1,00 50%	**0,93 42%**	0,99 49%	0,35
Ballast Nedam	1,17 18%	1,21 13%	**1,11 27%**	1,05 40%	1,00 49%	0,66 3%	0,18
BAM	1,00 51%	0,87 65%	**1,03 54%**	0,95 56%	**0,98 52%**	1,17 69%	0,33
CFE	0,79 24%	0,69 15%	1,61 2%	1,08 39%	0,88 34%	1,04 44%	0,30
Dura Vermeer	1,08 9%	0,95 21%	0,99 40%	0,95 23%	**0,94 15%**	1,01 44%	0,06
Heijmans	0,91 60%	0,96 54%	**0,91 61%**	0,79 73%	1,17 69%	1,13 65%	0,34
Strukton	0,97 46%	0,98 47%	0,98 47%	1,41 8%	**1,29 16%**	1,42 7%	0.29
VolkerWessels	0,87 35%	0,96 46%	1,00 50%	1,14 34%	**1,09 40%**	1,30 20%	0,35

Table 4.11: Probability of workload during years of procurement.

4.3.3.2. Partners

The seven project show a large diversity of partners for Croon, as well as for competitors. Croon regularly partners with TBI-sister Wolter en Dros and Mobilis and a large diversity of other contractors. Other contractors generally have not worked on infrastructure projects together. Notable exceptions are Heijmans and Ballast Nedam, who work together on multiple projects, and BAM and Cofely who enjoy a long working relation.

The quality of these partnerships, as well as that of the top competitor is assessed by determining the absence or existence of trust, commitment and satisfaction in the relationship between partners. These three elements are generally understood as forming the basis for relationships(Zolkiewski, Turnbull, Ulaga, & Eggert, 2006).

Only commitment and satisfaction in the relation are used. These are measured using number of projects in the past 5 years and number of won projects respectively. Measuring the trust competitors have in their partners is nearly impossible at the start of a tender. Sometimes not all competitors are known and in other instances obtaining this knowledge from a competitor will be very hard. Trust is therefore not used as a measure of relationship.

Every element is scored from (- -) to (+ +) based on the strength of evidence for commitment and satisfaction. The total number of (+) and (-) is added up, and the score is than added to a grade 5 reflecting the quality of the relationship in a grade from 0 to 10.

Table 4.12. shows Croon did not have a better relationship with its partners for the contracts it won than competitors did. For the Rotterdamsebaan contract however there was a very large difference in relationship, Croon was working with a number of first time partners whilst BAM had a proven relationship. Overall there is no discernible influence of Partners on project performance.

		VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Croon's relations with partners	Identity	Siemens	Mobilis / Wolter & Dros	Arcardis	VINCI / CFE		BAM	
	Commitment	+	++	0	--	N/A	++	
	Satisfaction	0	+	0	-	N/A	+	
Total		+	+++	0	---		+++	
Total score		6	8	5	2	////	8	////

Top Consortium	Identity	Spie / Dura / Besix	CFE / Cofely	Vialis / Volker-rail	BAM / Ways & Freitag	N/A	Hochtief / VolkerWessels	BAM / Cofely
	Commitment	++	++	+	++		+	+
	Satisfaction	+	0	+	+		+	+
Total		+++	++	++	++++		++	++
Total score		8	7	7	9	////	7	7
Difference		- 2	1	- 2	- 7		1	

Table 4.12: Relationship with partners for Croon and the winning consortium.

	VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Croon's share in the project	31,5%	48%	60%	25%			50%

Table 4.13: Croon's share of the total contract value.

4.3.3.3. Client

All clients for the projects under investigation are public sector clients, either municipalities of large cities or the Dutch government, represented by the executive agencies Rijkswaterstaat or ProRail.

	VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Who was the Client?	RWS	Rotterdam	RWS	Den Haag & RWS	Amsterdam	RWS	KeyRail
What client type sector	Public	Public	Public	Public	Public	Public	Semi-Public

Table 4.14: Identity and type of client.

4.3.3.4. Experience

A large diversity in experience can be seen amongst bidders. Generally an experienced party will win the contract. Being the *most* experienced is not a guarantee to win however.

		VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Number of similar projects in 5 years before project	Top competitor	2	Unknown	1	3	2	3	2
	Croon / TBI	4	4	1	0	1	0	0
Difference		+ 2	+4	+0	- 3	- 1	- 3	- 2

Table 4.15: Number of similar projects undertaken in the past years for Croon and the best competitor.

4.3.3.5. Contract type

Contract type contains three categories; contract conditions – the contractual relationship between the client and contractor - work type, and EMAT conditions – the system used for scoring and comparing EMAT.

Contractual relationships are determined by the contract standardization and the type of remuneration scheme. Contract standardization measures the degree to which a contract is standardized to FIDIC or similar contract standards. All contracts utilize fixed price remuneration and almost all are highly standardized. This can most likely be attributed to the uniformity in client type. The two exceptions are a municipality and a PPS, both designed their own contracts leading to low standardization. Remuneration or standardization have no effect on competitiveness for these projects.

Work included and contract integration determine the work included in the contract. Croon appears to have a preference for less integrated contract, which are less complex. On Design and Build contracts for simple(r) activities Croon wins more often. However these are also the projects where Croon is working solitary, without partners. It is impossible to exclude such a correlation.

Finally EMAT conditions have a large influence on Croon's competitiveness. EMAT bidding freedom is determined according to formula 4 and greatly influences the Croon's competitiveness; in contracts with high bidding freedom Croon does not manage to win. A majority of these contracts is won on price based formula 5. Out of the contracts won by Croon only one was won on quality.

$$Bidding\ freedom = \frac{Max\ EMAT\ discount}{Maximum\ price} \qquad (4)$$

$$Price_{winner} < Price_{best\ loser} - 0{,}8\ Max\ EMAT\ discount \qquad (5)$$

The last type of EMAT conditions measured is the type of scoring method used. According to Dreschler, when citing Doornbos (2005), three types of systems exist; point based, price corrected and value/price rating. All but one project use price corrected scoring, a conclusion on the impact this has on the competitiveness of Croon cannot be reached.

	VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Contact standardization	High	Low	High	High	High	High	Low
What type of remuneration scheme is used?	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Contract integration	D&B	D&B	Maintenance	D&B	DBM	DBFM	Maintenance
Work included	Tunnel Installations	Tunnel Installations	Canals, Sluices	Roads, Tunnel construction & Installations	Mass transit	Roads, Tunnel construction & Installation, Overpasses, Bridges	Railway, Tunnel Installation
Bidding freedom	25%	21%	27%	24,9%	108%	40%	150%
Quality	Price	Price	Quality	Price	Price	Quality	Quality
Scoring method	Price Corrected	Price Corrected	Price Corrected	Price Corrected	Price Corrected	Price Corrected	Point based

Table 4.16: Contract standardization, scoring method and type of work included for the case study projects.

As can be concluded from table 4.15. bidding freedom, contract integration, and work included in the contract influence competiveness of Croon on these contracts. Other variables are very similar for every contract and show little differentiation in competitiveness.

4.3.3.6. Sustainability

Because sustainability is becoming of increasing importance in construction it has been removed from Contract Type. Sustainability does not determine the characteristics of projects very much. In only three projects a criteria relating to sustainability was included, of which two projects directly translated the level of ambition for CO2 reduction into a discount. All contractors participating in the tenders shared this ambition, thus removing the necessity of this EMAT criterion.

	VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Bidding freedom for sustainability	5%	0%	5%	4,9%	0%	0%	0%

Table 4.17: Bidding freedom available to sustainability.

4.3.3.7. Contract size

The average contract size is €36 million, excluding two outliers of €300 and €480 million. The other contracts range from €17 million to €63 million. Award of a contract is grounded primarily in price; bidding freedom is usually around 25%. In 4/7 projects price directly determined the winner. In the remaining three price was very close, and quality was used twice to determine the winner.

	VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Was Price or Quality the determining factor (could #2 win the contract had he scored higher)?	Quality	Price	Price	Quality	Price	Price	Quality

Table 4.18: Prevailing EMAT tender determining factor.

4.3.3.1. Risk

Risk is identified by Croon using a metric for five disciplines for example project management and size, each on a scale from 1 to 5. When the combined project score is greater than 17 the project is deemed high risk. All project have a score over 17. In some cases the project risk score has not been determined but according to Cornet (2016) would be greater than 17. Because of the nature of the metric all projects undertaken in infrastructure are high risk projects. Croon does not employ a separate mechanism which can handle high risk infrastructure projects. A differentiation based on project risk can therefore not be made.

4.3.3.2. Location

The influence of location is measured using three methods. First the provinces in the Netherlands determine the location of a project, secondly distance from Croon's headquarters and finally distance from the divisional headquarters is measured.

All projects but the MA TTI Betuweroute and Renovatie Ijsselmeer are located in North or South-Holland. As can be seen in table 4.11. distance does not affect competitiveness; the longer distance contracts have all been lost but two long distance contracts have been won.

	VIT2 TTI	**Renovatie Maastunnel**	**Onderhoud Ijsselmeer gebied**	**Tunnel Rotterdamsebaan**	**CBI Metro Amsterdam**	**Gaasperdammerweg**	**Betuweroute MA TTI**
Distance from Headquarters	15-65km	3 km	63-145 km	20 km	60 km	53 km	15-110 km
Distance from Infrastructure headquarters	24-55 km	12 km	57-130 km	8 km	54 km	48 km	15-120 km
Average distance from Headquarters	40 km	3 km	100 km	20 km	60 km	53 km	62 km

Table 4.19: Location from headquarters for case study projects.

Figure 4.16: Location of the case study projects.

4.3.3.3. *Quality of Assets*

	2010	2011	2012	2013	2014	2015
Project procurements started in year (running years)			Ijsselmeergebied (2) Gaasperdammerweg (3)	Metro Amsterdam (1)	VIT 2 TTI (1) Rotterdamsebaan (2) Betuweroute MA TTI (2)	Maastunnel (1)
% LBO schooled			7%	9%	6%	6%
% MBO schooled			58%	76%	61%	54%
% HBO schooled			16%	15%	28%	32%
% WO schooled			0%	0%	6%	9%
% Wrong function level			44 %	27%	26%	30%

Table 4.20: Schooling and function levels from 2010-2015.

Personnel is measured by Croon according to their highest level of education. Every function in the company has an expected education level. Croon does not keep detailed records of personnel performance. Furthermore information of performance on individual projects was not available for this research.

Two measures were extracted from this data; firstly the percentage of people in a wrong function level, either because they were over or undereducated. Secondly the number of people in each function in a certain year.

No conclusions for Quality of Assets can be drawn based on this yearly information because Croon won a contract in every year but 2013. It is possible to observe a trend however; Croon is moving from a low(er) Education Company focussed on execution towards higher education and engineering and project management.

	2010	2011	2012	2013	2014	2015
Project procurements started in year (running years)			Ijsselmeergebied (2) Gaasperdammerweg (3)	Metro Amsterdam (1)	VIT 2 TTI (1) Rotterdamsebaan (2) Betuweroute MA TTI (2)	Maastunnel (1)
Monteur			10	13	27	25
Werkvoorbereider			6	7	8	7
Technisch Administratief			6	6	3	2
Technicus			5	10	12	13
Manager			3	3	4	9
Projectleider, PL-01			3	4	4	5
Coördinator			2	1	1	0
Projectleider, PL-03			2	4	3	3
Inbedrijfsteller			2	3	2	2
Leerling			2	1	0	0
Uitvoerder			1	2	6	5
1e Monteur			1	1	5	5
Chefmonteur			1	1	2	1
Consultant			0	0	30	30
Engineer			0	0	1	5
Projectleider Techniek, TPL-02			0	0	1	1
Voorman			0	0	1	2
Hoofdmonteur			0	0	3	2

Table 4.21: Employees allocated to different functions within the Infrastructure division from 2010-2015.

4.3.3.4. Competition

Competition is measured by the success and number of competitors who participated and their competitiveness with regard to the lowest bid.

The first method for testing influence of competitors is to measure the individual qualities of competing contractors. Based on the number of participating contractors per tender an average of 20-33% can be expected. Only contractors bidding on more than one contract are considered.

The most successful bidders are BAM and Siemens, with a winning % of 67% and 100% respectively. Their quality seemingly lies in bidding for only a few projects. Nonetheless other competitors; Besix, CFE, Dura Vermeer, Hochtief and VolkerWessels bid for less than four project yet do not manage to win one. Cofely and Croon are direct competitors providing very similar services never working together. Both win around 50% of projects. Some competitors are definitively more successful than others.

Identity	# of tenders won	# tenders lost	Win % when bidding
BAM	2	1	67%
Besix	0	2	0%
CFE	0	2	0%
Cofely	2	2	50%
Croon	3	4	43%
Dura Vermeer	0	2	0%
Hochtief	0	2	0%
Siemens	2	0	100%
VolkerWessels	0	3	0%

Table 4.22: Success of competitors.

Bid competiveness is the second variable and is determined as the price-ratio of an entered bid to the lowest bid. according to formula 7 (D. Drew et al., 2001). Where x_n is the bid by competitor x, and x_1 is the lowest bid.

$$\text{BCP} = 100\,\frac{(x_n - x_1)}{x_1} \tag{6}$$

There are two contracts which are of interest when regarding bid competitiveness. Firstly in the IJsselmeergebied contract two contractors; VolkerWessels and Cofely have a significantly higher price than Croon even though 4 contractors participated. Secondly the CBI Metro Amsterdam contract has an average BCP of 6, 82 which is caused by an enormous amount of EMAT discount available. Finally the number of competitors has no influence on competiveness.

In conclusion; competition measured by number of competitors and their bid competitiveness percentage does not have an influence on Croon's competitiveness for these projects. It is possible the identity of competitors has influence on the probability of winning for Croon.

		VIT2 TTI	Renovatie Maastunnel	Onderhoud Ijsselmeer gebied	Tunnel Rotterdamsebaan	CBI Metro Amsterdam	Gaasperdammerweg	Betuweroute MA TTI
Bid competitiveness percentage	Croon	1,00	1,00	1,00	1,03	8,05	1,27	1,25
	Competitor (a,b,c,d,)	1,11	1,32	1,11	1,00	1,00	1,00	1,02
		1,21		1,43	1,12	11,40	1,12	1,20
				1,52	1,22			1,11
								1,00
Number of competitors		3	2	4	4	3	3	5
Average BCP		1,11	1,16	1,27	1,09	6,82	1,13	1,12

Table 4.23: Bid competitiveness percentage for Croon and competitors.

4.4. Scorecard

The performance of every factor, and its sub factors, measured in section 4.3. is recorded in table 4.24. Every sub factor in the table corresponds to one of the measures used for determining the influence of a factor on competitiveness.

The result for every factor are summed in the bottom row. This shows 5 factors with a clear influence (+) on project performance. There is 1 factors with no influence (-), and 5 factors for which there is not conclusive evidence (0). The factors are described below.

	Workload	Partners	Client	Experience	Contract type	Sustainability	Contract Size	Risk	Location	Quality of Assets	Economic conditions	Competition
Sub factor 1	+	0	0	+	-	+	+	0	0	0	0	+
Sub factor 2	-	0			0				0	0		0
Sub factor 3					+				0			0
Sub factor 4					+							
Sub factor 5					+							
Sub factor 6					0							
Total	0	0	0	+	+	+	+	0	0	0	0	+

Table 4.24: Scorecard summary of factor influence on competitiveness.

4.4.1. No influence

Workload has some strong evidence indicating workload has a significant effect, not all project have complete data with regard to workload however. Other evidence indicates no relation between workload and project competiveness at all. Overall there is no conclusive evidence for workload as a significant factor. Partners similarly has some evidence, but overall is inconclusive.

As can be seen in table 4.24. the **type and identity of client** has any effect on the competitiveness of Croon. There is a slight majority of country government procurers, but this does not seem to have an effect on competitiveness.

There is also no evidence which supports **risk** as an important factor. This is primarily rooted in Croon's measurement system. There is also no evidence for **location** or **economic conditions.** Both of these factors are (near) constant for all seven contracts so differentiation is nearly non-existent.

4.4.2. Positive and negative

The first factor which changes the competitiveness of Croon is **experience**. On two out of three projects where Croon was able to win the company had built four similar projects. In all the projects it lost no experience was present.

Similarly bidding freedom with regard to **sustainability** influences the competitiveness of Croon. Projects with greater amounts of sustainability increase competitiveness, whilst more restricted projects have a lower probability of success.

One restricted contract was lost, even though Croon generally performs better on restricted contracts. This is most likely cause by **contract size**. Of the large contracts over €100 million Croon has lost all. This is further corroborated by Cornet, who argues large scale projects and their management is new ground for Croon.

Furthermore, this comment explains why Croon succeeds in relatively simple Design and Build contracts for Tunnel Installations, but fails whenever the **contract type** is more complicated or includes more complicated work. Croon's expertise lies with tunnel installations, and winning the contract for the maintenance of the Ijsselmeer would appear to be a fluke rather than core business.

Finally **competition** has some effect on project performance, the identity of competitors might determine who the winner will be. It does not change Croon's competitiveness however.

4.5. Conclusion

To answer the sub question which was put central in this chapter; *Which identified criteria influence competitiveness on case study projects?* The nineteen factor identified in the previous chapter as being important to either competitiveness or bid no bid are used in a case study analysis. Of these nineteen factors, seven were not usable in the case study project, they will return in chapter five.

In this chapter the remaining twelve factors were tested for their influence on Croon's competitiveness. Five key factors were identified to be of crucial importance when assessing the competitiveness of Croon for seven projects. They are:

- Experience
- Contract type
- Sustainability
- Contract size
- Competition

Furthermore another seven criteria were identified which had little or no effect on the bidding performance of Croon.

- Workload
- Partners
- Client
- Risk
- Location
- Economic conditions
- Quality of Assets

In the next section the identified key factors will be used as quantitative input, all other factors for the basis for a qualitative input in a multi criteria decision making framework.

Segment two - Design

In section two the framework for a bid / no bid decision based on the identified factors is designed and validated. First the tool itself is designed in three steps; standardizing, weighting and finally scoring. The second step in this section is the validation of the model using three types of sensitivity analysis

Figure 5.0: Tools for sale at the Tsukiji fish market. Source: https://temporarilylost.com/2012/08/31/sushi-sake-and-soy-sauce-consuming-and-imbibing-in-tokyo/tsukiji-fish-market-6-knives/

5. Tool design

In the previous chapter five key factors influencing competitiveness were identified. These factors will be used to design a bid / no bid tool incorporating both factors that definitely influence Croon's competitiveness and other, non-critical, factors. These factors were extracted from the literature on bid / no bid decision making and competitiveness in chapter three.

This chapter consists of three parts, each reflecting a stage in the design of the tool. The first part contains the method of scoring and soliciting data and the method of standardizing this data for both crucial competitiveness and bid / no bid factors.

The factors found to be of crucial importance are quantified and piecewise linear scoring functions are developed to standardize input in section 5.1. These factors return to influence the bid / no bid decision because this decision is not solely based on competitiveness, it also includes contract, strategic and other previously identified factors. For these other factors quantification is not possible; there is too little information upon which can be quantified. Rather, these factors are scored qualitatively, and standardized in section 5.1.

In the second part of this chapter the preference and consistency of decision makers is analysed. This information is used to determine weights for categories of factors, such as contractor, client or the project. Preference information is also used to determine weights for factors within.

The final section of this chapter describes the ranking process used to integrate both input and weights. The tool is then tested on four old and two new projects to determine if the tool works.

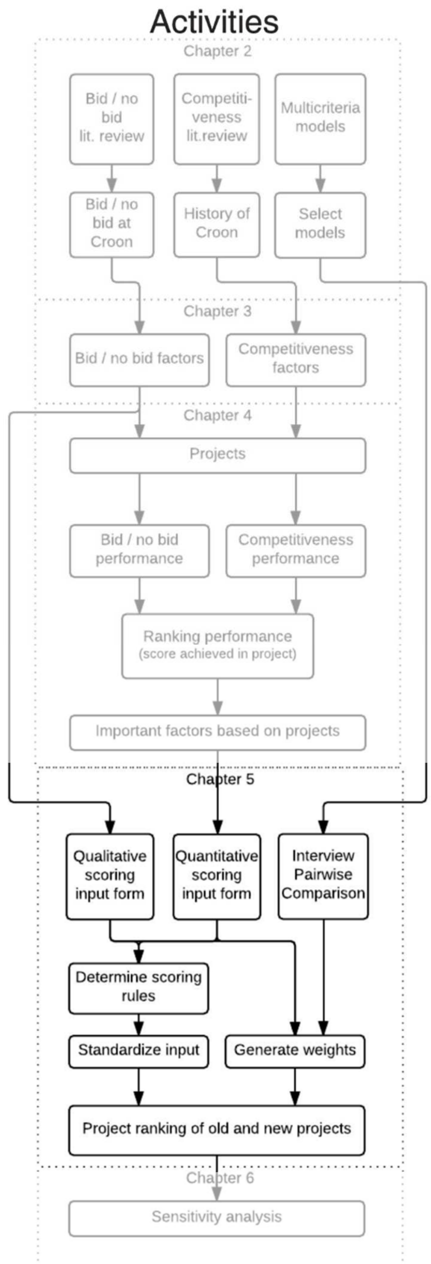


Figure 5.1: Position of chapter five in the research methodology.

5.1. Scoring and standardizing project data

The first step for creating the tool is obtain and standardizing project data. Standardizing questions and output data structures the input required from decision makers. In this section the method for obtaining input data for the tool is described, as well as the method used for standardizing. Finally scoring rules made using the Evidential Reasoning Approach are defined for every factor.

5.1.1. Generating the impact overview

The first step in determining a ranking of projects using a multicriteria method is establishing an overview of the impacts of every alternative on the criteria. The questions used to determine impacts can be seen in table 5.7.

They are split into quantitative and qualitative questions; quantitative questions use data obtained from the project, whilst qualitative questions are scored on a six point scale to conform to make transition into Evidential Reasoning input easier.

The qualitative questions were obtained by classifying Lewis's questions for every factor, and then selecting the best fit. Lewis does not include all factors in his book, for these factors Croon's bid / no bid forms were leading.

Quantitative questions were obtained directly from the crucial competitiveness factors in chapter four. These questions are identical to the input used to determine the effect of each factor on competitiveness.

In Appendix E.1. the questionnaire and scales used for determining impact can found. In Appendix E.2. and E.3. the questionnaire has been filled for five case study project and two new projects.

Quantitative Factor	**Question used for scoring**
Contract size	What is the contract value in €?
Contract type (bidding freedom)	How much is the estimated bidding freedom available in %?
Contract type (Integration)	What type of contract is the contract? (D&M, DBM, DBFM,DBFMO)
Experience	What is the difference in experience?
Success of competitors	What is the success of competitors?
Sustainability	How much is the estimated bidding freedom available for sustainability in %?

Qualitative Factor	**Question used for scoring**
Client Relations (Understanding)	How well do we understand the business needs of the client?
Client Relations (Contacts)	Will the contract bring you useful political or business contacts, enhance your professional standing and raise your profile in the market?
Client Relations (Future projects)	Does turning down this project reduce the chance of receiving more invitations from this client?
Client Type	Is the client a single entity or a group of organizations with different responsibilities?
Contract conditions (availability)	Are terms & conditions available at moment of Proposal and how 'special' are they according to legal?
Design and document quality	How good is the design and document quality?
Economic conditions	Does this contract open up new markets with good prospects for long term growth?
Innovations	Do we need to design or develop technology not available at <the contractor>?
Knowledge (challenge)	Will the contract offer a particularly interesting or stimulating professional challenge?

Location	Is the contract located in a place that is particularly congenial or particularly unpleasant to <the contractor>?
Partners (Quality)	How are <the contractor>'s relations with the partner of this project?
Partners (winning)	How important is (scoring) this project to partners?
Profitability	Will <the contractor> be able to apply its normal estimating figures for covering overhead, risk and profit?
Project Financial	Is there a risk that winning the contract might strain your financial resources?
Quality of Assets (bid manager)	Do we have someone available who can manage the bid effectively?
Quality of Assets (hire specialists)	Do we need to hire specialized staff to undertake this project?
Risk	How much risk is the contract likely to involve that<the contractor> is unable to accept, manage or transfer to the client?
Specialization (competencies)	Does <the contractor> have the required competencies or will the contract mean a steep learning curve?
Specialization (fate of last bid)	How good was the last bid we produced for this type of work? What was its fate?

Table 5.1: Quantitative and Qualitative questions used for obtaining factor input.

5.1.2. Standardizing project data using scoring rules

The first stage for creating a tool capable of formalizing the bid / no bid decision is transforming multiple types of data into a usable format for the people entering a project into the tool, decision makers and future use.

As we will see preference is not necessarily linear. For some factors, such as contract size, there is an optimum above and below which Croon becomes less competitive. By classifying data into categories both the order and difference in achieved score is preserved allowing for standardization whilst including preference information in the comparison (Verhaeghe, 2009).

5.1.2.1. Selecting a standardization method

A number of methods exists, of which the maximum score procedure and the score range procedure are most well-known.

In the maximum score procedure every entry for a criteria is divided by the maximum score present amongst alternatives, whilst allowing a distinction between positive and negative values. Distance between alternatives is preserved but the highest or lowest value is deemed most important.

The score range procedure takes an entry and places this within the total range of entries according to $x'ij = \frac{xij - xj\ min}{xj\ max - xj\ min}$. This does not preserve proportionality between comparisons, since values are standardized using the lowest and highest values in the comparison (Young, Rinner, & Patychuk, 2010).

Both of these methods are not desirable for the contract size criterion; this is a nonlinear criteria with an optimum value. Above and below this value contracts become less desirable.

Another method capable of incorporating this non-linearity is needed. In Evidential Reasoning every alternative is assessed to determine to what extent it is [worst, poor, average, good, excellent or top], where each criteria receives a piecewise linear function for determining scores.

Quantification will be applied to the five factors found to be of crucial importance to competitiveness in chapter five. One example of a quantitative piecewise function can be found below. The others can be found in Appendix E.4. For every factor a distinct rule is created transforming this qualitative data into one of the six belief degrees. This has the advantage of decreasing the number of inputs available when soliciting data thus decreasing the complexity of decision making. This now-structured data forms the input for the bid / no bid tool, and readies it for final comparison.

In Evidential Reasoning a criteria does not have to be either worst or poor, rather a degree of belief is assigned to the criteria. Using for example an acceleration of 8.8 m/s according to the function in figure 5.2. below leads to a score of [Poor 0.2 ; Average 0.8](Yang, 2001).

The advantage of this method is data of different types can be completely integrated into the tool without loss of information. Furthermore assessment outcomes are presented more informatively; instead of an abstract number a distribution of preference is made. Because of these advantages Evidential Reasoning will be used for standardizing both quantitative and qualitative data.

In the following section scoring rules are determined and for both qualitative and quantitative factors. Only for factors which have a definitive impact on competiveness will quantitative rules be determined. For all other factors qualitative rules will be used; in the previous chapters it was shown these factors have no demonstrable effect on competitiveness. Nonetheless they are important when making the bid / no bid decision. They will therefore be integrated as qualitative rules.

5.1.2.2. Transforming and standardizing project data using Evidential Reasoning

In the following section two examples of the scoring rules used in the Evidential Reasoning model for transforming data into belief structures are described. These scoring rules transform input into a belief structure, which reflects the prefer ability of an alternative. Rules are established based on the data on factors obtained and analysed for significance in chapter four. Every factor has a unique piecewise function, its generation is shortly discussed for every factor in this section.

Quantitative scoring rules are used for factors which have a definite impact on competitiveness. All other factors are assessed using qualitative scoring. In Appendix E.4. all used scoring rules can be found. Below one example of a quantitative rule, and the method for deriving it is described, followed by the qualitative rule used for all qualitative factors.

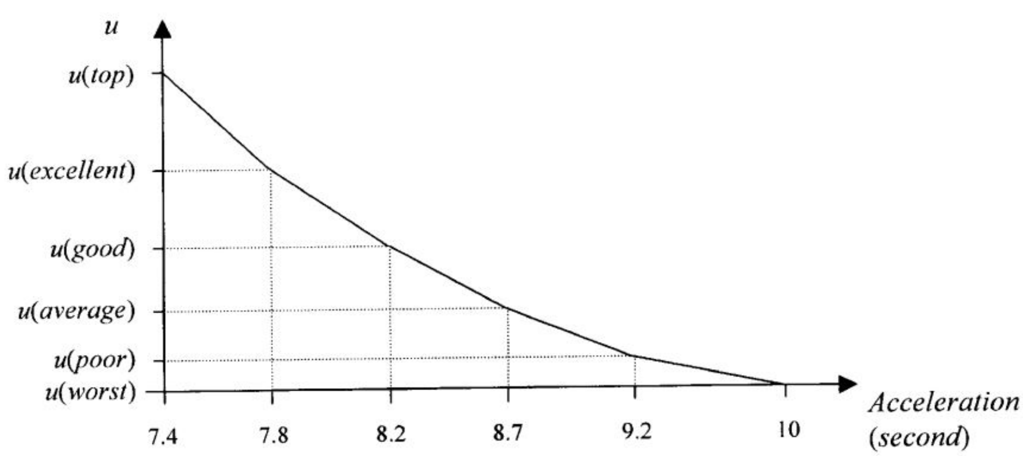


Figure 5.2 Piecewise linear function for Acceleration from Yang (2001, p. 47)

5.1.2.3. Contract Size

The average value of the contracts won by Croon is €46.000.000 with a standard deviation of €16.000.000. This is reflected in the scoring rule; the “top” score is €46.000.000 with linear decreasing scores for both higher and lower contract values until the average won or lost value is reached.

Average won value	Standard deviation won	Below average lost average	Above average lost average
€46.000.000	€17.000.000	€20.000.000	€391.000.000
Top		Good	Worst

Table 5.2: Contract size scoring function input.

According to D. Drew and Skitmore (1997) every contractor has a unique price range where it is most competitive. Figure 5.5. is therefore only applicable to Croon. Similar scoring rules for other contractors can be determined using the described methodology.

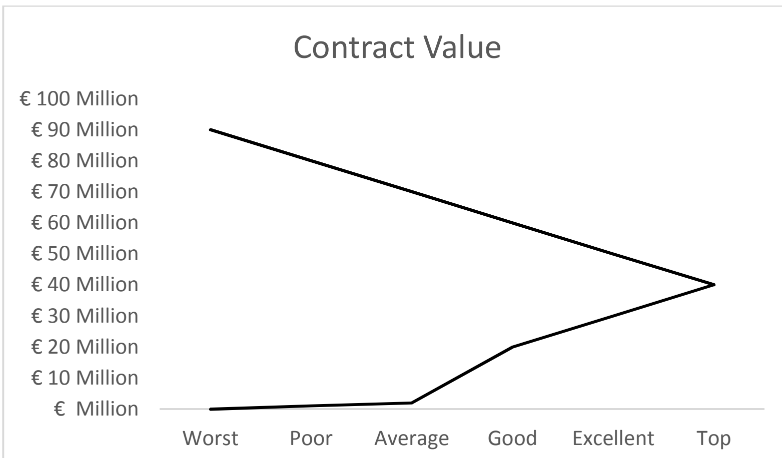


Figure 5.3: The scorings function generated for the Contract value factor.

5.1.2.4. Qualitative criteria, Risk and Client Relations

Two types of qualitative criteria and scoring functions can be determined. First qualitative criteria such as risk, where very high risk is undesirable, and equivalently very low risk is desirable. This leads to the scoring function in figure 5.9. with decreasing qualitative attributes corresponding to a higher score.

The opposite of such a function is an increasing function, where a higher quality corresponds to a higher score. An example of such a function is Client Relations. Better relations lead to a higher score.

For both criteria, and other qualitative criteria, no preference information is available therefore a linear scoring function is assumed. The qualitative input changes for every factor however all factors use the six step scale output of the Evidential Reasoning method. In some cases it is not possible to generate rules covering the entire range of qualitative input; for example Contract Integration has only four inputs. The score associated with these limited inputs is unique for each factor.

It is assumed qualitative rules are the same for all contractors based on competitiveness. In the bid / no bid decision other rules can be determined to incorporate for example an attitude with regard to risk.

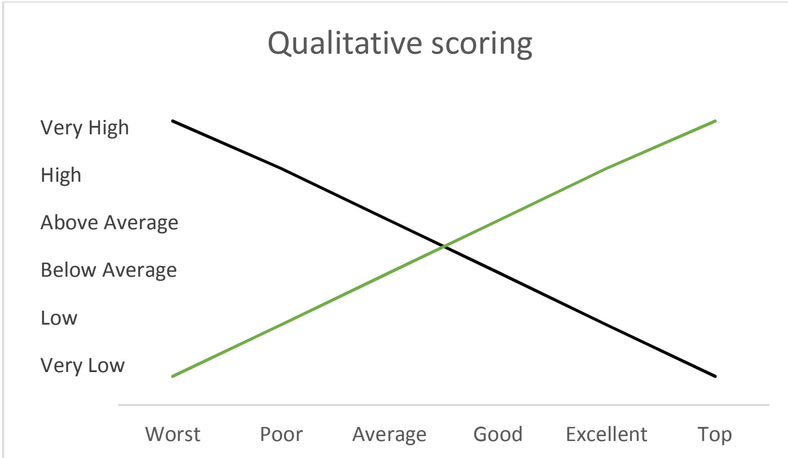


*Figure 5.4: The scorings functions used for the **all** qualitative factors.*

5.2. **Weight generation**

The next step in designing the tool is determining the weights each factor should have. According to Wang and Luo (2010) the weights of criteria play a significant role in the process of decision making. Therefore the method for determining the weights of criteria is of great importance.

Because there is no hard evidence supporting a particular set of weights the Analytical Hierarchy Process (AHP) method will be used to determine weights. The advantage of the AHP is that it does not require direct ranking and comparison of all criteria. Rather, it focusses on pairwise comparisons between criteria. Furthermore using a subjective method is preferred for this research because it directly involves decision makers in generating the tool, hopefully leading to acceptance of the tool in business processes.

The Analytical Hierarchy Process dictates a three step method; first the problem is broken down into a number of categories. Then all factors are compared in a pairwise fashion on a 1-9 scale. Finally this preference information is used to determine the eigenvector of the solution and thus the weights.

In the following section important factors according to decision makers, the categorization used for combining factors and creating the structure of the tool, and weight generation can be found.

5.2.1. Important factors to decision makers

To obtain preference information about the most important factors to decision makers a number of decision makers were questioned in a semi-structured interview. The primary goal was obtaining a number of pairwise comparisons in order to generate a weighting set for the tool. This has the added benefit of also allowing an insight into the preferences of a decision maker.

Three decision makers were interviewed this way, one of whom was available for continued interviewing to obtain the data needed for weight generation. Below the preferences are compared and some conclusions about their preferences are drawn.

5.2.1.1. Bid / no bid factor preference

In table 5.3. below the preference ranking every interviewee has for eight factors is displayed. This ranking was created using the Analytical Hierarchy Process. It should be noted interviewee one and three are considered inconsistent in their appraisals. Nonetheless the information they provided will be used for determining their preferences, and more importantly for comparing them to the preference of interviewee two.

The decision makers do not agree on the importance of factors. Some conclusions can be drawn however. Firstly they all think experience is of high importance. Furthermore need for work should only have a small influence on the bid / no bid decision, as they all value it low.

Thirdly the Quality of Assets available at the company is valued high by interviewee one, and lower by the other interviewees. This might be explained by the expectations Croon has of interviewee one, he needs to have a more strategic view the other two interviewees, therefore managing assets is more is more important to him.

Finally Innovation and Partners are valued differently. Partners are valued highly by both interviewee two and three, but carry little importance to interviewee one. This can most likely be explained by the day to day operations both interviewee two and three carry out. They work with partners a lot, and are involved in keeping them on board. Interviewee one does not have these responsibilities. For innovation such an argument cannot be made as both divisional heads disagree about the importance of innovation. This might be rooted in a number of other factors amongst which age or work experience.

Interviewee	1 - Managing director	2 - Infrastructure	3 - Heavy Industries
Consistency ratio	0.45	0.05	0.33
High importance	Experience	Risk	Innovation
	Quality of Assets	Partners	Experience
	Innovation	Experience	Partners
Moderate importance	Contract size	Quality of Assets	Competition
	Risk	Competition	Quality of Assets
Low importance	Need for Work	Innovation	Risk
	Partners	Need for Work	Need for Work
	Competition	Contract size	Contract size

Table 5.3 important factors according to decision makers

Degree of agreement	Description
Agreement	All in one class
Small disagreement	One disconsenting opinion, max 1 class
Moderate disagreement	One disconsenting opinion, 2 class
Large disagreement	Multiple disconsenting opinions

Table 5.4 legend for table 5.3. showing degree of agreement

5.2.1.2. Conclusion

The three interviewed decision makers agree about the importance of Experience when making a bid / no bid decision. Furthermore Need for Work shouldn't govern the bid / no bid decision according to them. Finally a number of factors (Quality of Assets, Partners and Innovation) are important to some decision makers but not all. This appears to be mostly rooted in the type of function within which they are employed.

5.2.2. Categorization and tool structure

In the tool a project will be compared to multiple other project to the other projects using the factors found in the previous chapter. As stated before the AHP method requires the decision problem to be prioritized using a hierarchy. The AHP model for this decision problem is split in five categories to reflect the types of factors in the tool. Furthermore according to the EvaMix method quantitative and qualitative factors are treated separately and only in the end reconciled. The division into qualitative and quantitative factors is schematically displayed in figure 5.5.

Finally a preference, and weighting decision must be made with regard to both factor types. For the first iteration of the tool a 50%/50% weight will be used because no preference information is available from decision makers. Furthermore qualitative factors and their input are highly valued by decision makers. Overreliance on only five qualitative factors should be avoided, therefore a 50%/50% weight is used in the first iteration of the tool, a new weighting set can be developed based on the sensitivity analysis in chapter six if the results are not robust.

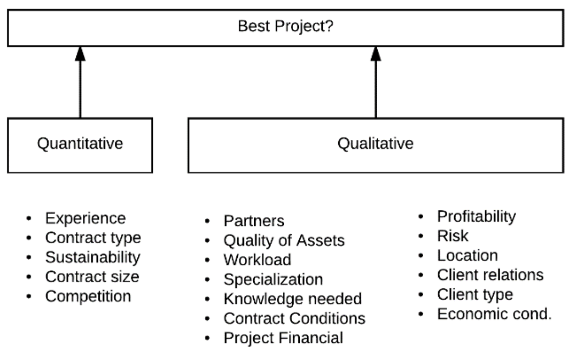


Figure 5.5: Categorization into Quantitative and Qualitative factor types with factors included.

As described in chapter one and two, the literature views factors in both competitiveness and bid / no bid decision making as a being part of large categories. Categorizing will therefore also be used in this research. This has the added advantage of placing similar factors in the same category, thereby decreasing the total weight allocated to factors that might be dependent.

The categories used have been proposed by Jarkas et al. (2013). Many other categories, both broader and narrower exist but the categories by Jarkas et al. summarize and contain the categories proposed by other authors as is visible in table 5.5.

Jarkas et al (2013)	Carr & Sandahl (1978)	Ahmad (1990)	Bagies & Fortune (2006)	Enshassi et al. (2010)
Employer			Client characteristics	Client related factors
Project	Job characteristics	Job related	Project characteristics	Contract/Project related
Bidding situation	Economic environment Competition condition	Market related	Bidding situation Economic situation Competition	External market conditions and strategic considerations
Contract			Contract characteristics Project finance	
Contractor		Firm related Resource related	Business benefits Company characteristics Company previous experience	Contractor related

Table 5.5: Categorizations available in bid / no bid literature.

5.2.2.1. *Categories for qualitative factors*

The five categories each contain factors relevant for the bid / no bid decision, but relating to different perspectives on the problem. The subdivision into these five categories is echoed in the categories employed by Croon in bid / no bid forms. The five categories are shortly introduced below.

The category **Client** contains factors direct related to the identity and relationship with the contractor's employer. **Project** contains factors directly related to the project, such as size and risk profile. In **bidding situation** factors relating to the market and competition are combined. The **contract** category contains factors specific to the contract which is used for the project, such as the payment scheme or contract type. Finally **firm/contractor** incorporates the factors determined by strategy and situation, and experience of the contractor.

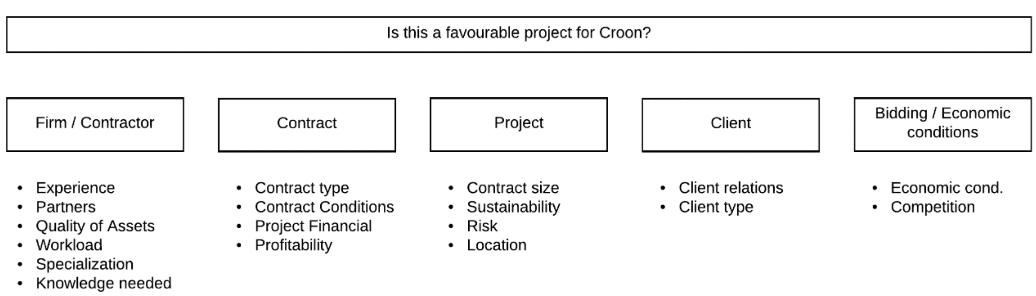


Figure 5.6: Employed bid / no bid categories for in the tool.

5.2.2.2. *Qualitative weight generation*

An important step in the AHP is the generation of weights. This is done using pairwise comparisons as described in the introduction to this section. Pairwise comparisons by the head of Croon's Infrastructure division can be found in Appendix E.6. These pairwise comparisons lead to the weights displayed in table 5.6.

The weight displayed are later multiplied with their factor type (quantitative or qualitative), in the interest of readability and to emphasize preference the weights before this multiplication are used throughout this report.

Category *(cat. weight)*	**Contractor *(34%)***	**Contract *(34%)***	**Project *(18%)***	**Client *(14%)***	**Bidding / Economic situation *(3%)***
Factor *(factor weight)*	Partners *(6%)*	Contract type *(51%)*	Risk *(83%)*	Client relations *(83%)*	Economic conditions *(13%)*
	Quality of Assets *(21%)*	Contract conditions *(31%)*	Location *(17%)*	Client type *(17%)*	
	Workload *(20%)*	Project Financial & Profitability *(18%)*			
	Specialization *(16%)*				
	Knowledge needed *(37%)*				

Table 5.6: Qualitative weights generated by pairwise comparisons.

These are the weights that will be used for the tool. It is important to determine the consistency ratio of judgements presented by decision makers. After a multiple consultations all judgements have a consistency ratio below 10%, this is generally deemed the threshold for consistency and reliability (Saaty, 1988).

5.2.2.3. *Quantitative weight generation*

Similarly quantitative factors need to weighted. Because there are only five factors they are not categorized any further. Pairwise comparisons by the head of the Infrastructure division of Croon determine the weights to be used. The pairwise comparisons can be found in Appendix E.6., whilst the results are displayed in table 5.7. below.

Factor *(factor weight)*	Experience *(48%)*	Contract Size *(7%)*	Sustainability *(26%)*	Contract type *(15%)*	Success of competition *(4%)*

Table 5.7: Quantitative weights generated by pairwise comparisons.

5.3. Integration and project ranking

In order to create a tool which meets the requirements set in chapter two the data generated by the Evidential Reasoning Approach and the Analytical Hierarchy Process needs to be integrated. As was described in chapter two, EvaMix will form the basis for doing so. This leads to a tool with three distinct parts as can be seen in figure 5.7. In this figure every color corresponds to one of the three parts. Their function is displayed in the top of the graph, whilst the bottom half elaborates on this with substantiated categories and factors.

The AHP forms the input for weighting, whilst Evidential Reasoning standardizes data. EvaMix is used to integrate both types of information and assess a project. In the following section the process used to integrate this information and create a ranking is described. Finally the ranking based on four case study and two new projects is presented.

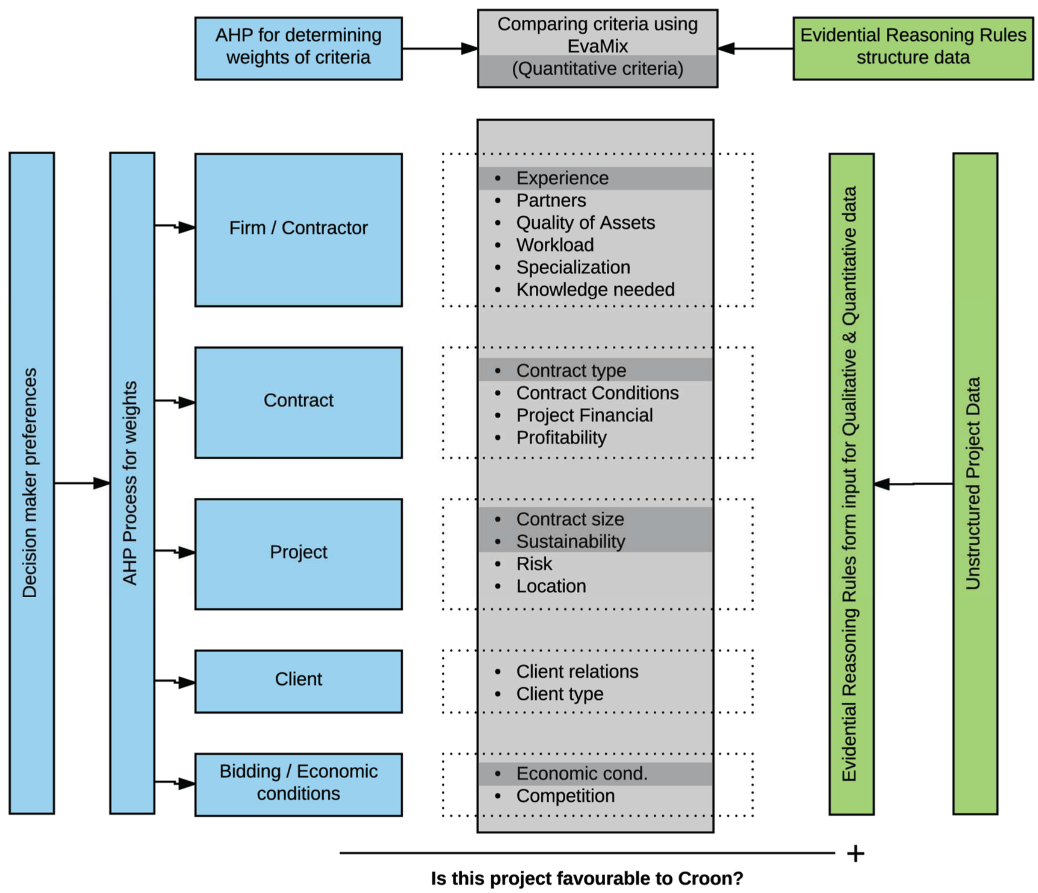


Figure 5.7: The proposed bid / no bid model with its inputs and comparison colour coded. Source: own illustration.

5.3.1. Ranking process

The process for determining the ranking has ten steps. It is largely based on EvaMix and uses input from Evidential Reasoning for standardizing data, and the Analytical Hierarchy Process for generating weights. The method can be split into three levels based on the hierarchical level it fills in the tool; either factor, category or project level. The levels and the actions required are described below.

Factor	1. Solicit input using a form 2. Standardize input using ER 3. Generate concordance matrix using pairwise comparisons per factor 4. Generate factor weights using AHP 5. Assign generated factor weights to highest scoring project in each pairwise comparison
Category	6. Sum up assigned weights for all factors into category matrix 7. Sum up category matrix into qualitative/quantitative matrix 8. Standardize summed up matrix
Project	9. Multiply standardized matrices by (quantitative or qualitative) weights and sum up 10. Sum up rows in combined standardized matrix 11. Rank projects based on summed up rows

Factor

The factor level of the tool is the lowest level. Collecting data and using it to determine the input for the tool using ER are some of the first steps. This data is then used to generate concordance matrices which form the input for assigning weights to each project. These weights are generated by the AHP and assigned the project which scores the higher of the two projects being compared.

Category

The category level of the tool is the intermediate level. It combines the scores per factor to generate a score overview per category. These scores are summed up to generate a qualitative and quantitative matrix, based on the type of data used as input. Both matrices are (separately) standardized using the positive sum of the entries, after which they are ready for the final level.

Project

The final level is the project level. In this level projects are compared and the results are generated. This is done by multiplying both standardized matrices with assigned weights according to the data type (qualitative or quantitative weights) and summing up both matrices. After summing up every row in this matrix a score per project is obtained, which is compared to the scores the other projects obtain to create a ranking.

5.3.2. New Projects, colour coding & ranking

To test the tool and determine its usability, two project were selected at Mobilis, a sister company to Croon. They are both smaller than the case study projects. Nonetheless their contract value is over the threshold set for this tool (€5.000.000) and both projects use and EMAT appreciation method. Both projects are introduced and then compared below.

5.3.2.1. Bicycle storage Amsterdam

Amsterdam-South railway station and the A10 highway will be reconstructed in the foreseeable future. Because of the reconstruction a large number of bicycle storage places will not be usable anymore. Furthermore the number of people travelling to Amsterdam-South by bike is increasing and current facilities are no longer sufficient.

The Bicycle storage Amsterdam contract contains the design and construction of 3000 storage places underground, below the Mahlerplein. The contract value has been estimated at €8.200.000 and is a D&B contract for the Amsterdam municipality. This was the first bicycle storage Mobilis tendered for, and the tender was lost.

5.3.2.2. Bicycle storage Maastricht

The second Mobilis project is the construction of Bicycle storage in Maastricht. Just like in Amsterdam the number of bikers is increasing and space in the city is at a premium. Therefore an underground bicycle storage underneath Stationsplein was desired.

The contract, for both the Maastricht Municipality, ProRail and NS has a value of €8.000.000 and is of the Design and Build type. The tender was won.

5.3.2.3. Coding findings

To increase legibility to decision makers outcomes can be colour coded based on the scores achieved in the comparison. Colour coding enables decision makers to quickly assess the desirability of the project under investigation.

Three tool outcomes can be defined to assist designing colour coding:

- High scoring and successfully tendered projects
- Low scoring and unsuccessfully tendered projects
- Intermediate projects

By comparing to the set benchmark of five known projects and their results some information can be obtained about the project under review. If it scores between or higher than the two won projects (VIT 2 TTI and Maastunnel) participation is encouraged.

Similarly, if the projects scores between or lower than the lost projects (Betuweroute, Rotterdamsebaan and Gaasperdammerweg) participation is discouraged. If the project scores in between both won and lost projects reaching a conclusion is harder. To assist decision makers a threshold has been set; if a project scores very close to the highest lost project an advice for additional investigation is given. If it scores closer to a won project participation is recommended. Finally the project is positioned in the space between the won and lost projects, and the project is coupled to a success rate based on its distance to the other projects. This is further clarified in figure 5.8.

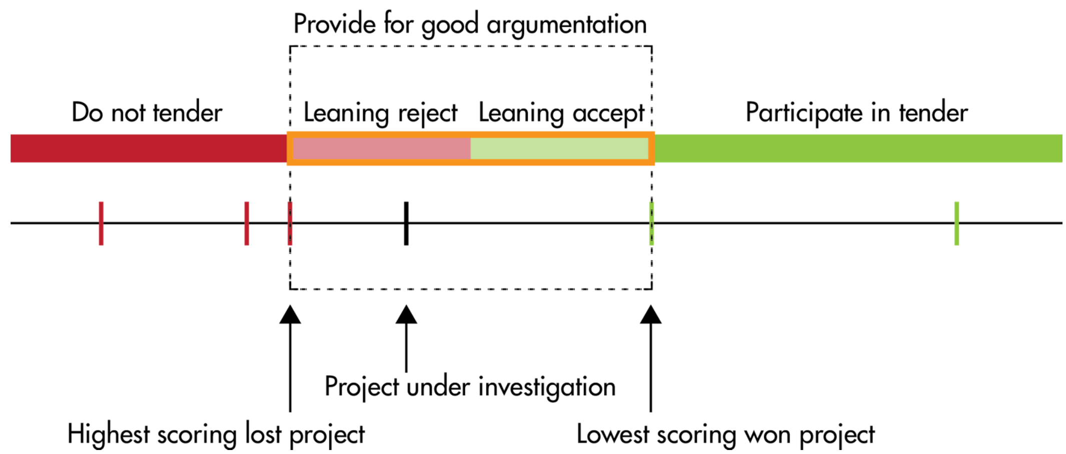


Figure 5.8: Bid / no bid tool decision making advises. Source: own illustration.

As can be seen in figure 5.8. the intermediate area between won and lost projects requires good argumentation for participating in or rejecting a tender. The basis, and a part of the reasoning for this argumentation can be provided by the tool. As can be seen in table 5.9. constituent scores can be displayed on a factor level, allowing decision makers to quickly assess the strengths and weaknesses (in comparison to other projects) of a project.

5.3.2.4. Results

The outcomes and scores for both new projects are displayed below in table 5.9. As can be seen Amsterdam scores significantly lower than Maastricht. They are still both in the intermediate area though. This indicates more investigation is required to come to a sound argumentation. This can be done based on constituent score – the rank achieved on each factor. This is shown in table 5.9. and 5.10.

As can be seen in these tables Bicycle storage Maastricht scores low primarily on location and success of competitors. The bicycle storage in Amsterdam on the other hand scores predominantly high, but very low on Specialization, Experience and competitors. Participating in the Amsterdam project is discouraged, participating in Maastricht is encouraged. This is in line with the success of both tenders at Mobilis.

Rank	Summed score	Project name	Possible actions	Remarks	Success rate
1	0,26	VIT 2 TTI			
2	0,22	Maastunnel			
3	0,13	Bicycle storage Amsterdam		More investigation required	22%
4	0,11	Rotterdamsebaan			
5	-0,24	Betuweroute MA TTI			
6	-0,49	Gaasperdammerweg			

Rank	Summed score	Project name	Possible actions	Remarks	Success rate
3	0,20	Bicycle storage Maastricht	Participate in Tender		77%

Table 5.8: Coded results for Bicycle storage Amsterdam.

Constituent scores	Rank
Experience	3
Partners	1
Quality of Assets	2
Workload	1
Specialization combined	2
Knowledge combined	1
Contract type combined	2
Contract conditions	3
Project Financial	1
Design and document quality	2
Contract Value	2
Sustainability	3
Risk	3
Location	6
Client Type	4
Client Relations combined	1
Economic conditions	2
Succes of Competitors	5

Table 5.9: Constituent scores of Bicycle storage Maastricht output available for more investigation.

Constituent scores	Rank
Experience	5
Partners	1
Quality of Assets	2
Workload	2
Specialization combined	6
Knowledge combined	1
Contract type combined	2
Contract conditions	1
Project Financial	1
Design and document quality	2
Contract Value	2
Sustainability	1
Risk	3
Location	2
Client Type	4
Client Relations combined	1
Economic conditions	2
Succes of Competitors	5

Table 5.10: Constituent scores of Bicycle storage Amsterdam output available for more investigation.

5.4. Conclusion

The first section of this chapter dealt with standardizing input, and generating decision rules based on Evidential Reasoning for both qualitative and quantitative factors. These rules are unique for the quantitative factors. For qualitative factors a generic rule is used because there is no preference information. The resultant scoring rules can be found in Appendix E.4.

The second section of this chapter describes the preferences of decision makers and leads to weight generation. Based on three interviews Experience is a seen the most important factor according to decision makers when making a bid / no bid decision. Quality of Assets, Partners and Innovation are critical to some decision makers but not all. Additional interviews with one decision maker were used to generate weights for the factors used in the tool, using the Analytical Hierarchy Process.

This results in an emphasis on Contract and Contractor categories, both account for 34% of the qualitative side of the tool. Within these categories Knowledge, Quality of Assets, Contract conditions and Contract type were most important. On the quantitative side of the model Experience and Sustainability receive the most emphasis.

Six project, scoring using the determined scoring rules, were compared using the Evamix method selected in chapter 2.3. This results in an eleven step bid / no bid tool capable of generating a ranking of the selected projects. This ranking can be codified to generate an advice to decision makers. An additional capability of the tool is generating constituent scores for the project under investigation. This allows for a more detailed investigation into the bid / no bid advice, as well as a guide for evaluating the decision made.

6. Sensitivity analysis

In this section a sensitivity analysis will be conducted. According to Saltelli et al. (2008) all scientific models contain a degree of uncertainty and sensitivity analysis is conducted to determine the sources of outcome uncertainty.

The large number and nature of inputs for this tool appears to make it quite robust; the method proposed by Triantaphyllou (2000) for determining critical weights and factors produces no critical factors. In this method weights are transformed according to their final performance scores divided by the input scores as described by equation 7. For this research one critical condition is applied; weights can change at most plus or minus 100%. Because the weights used are small no one factor can reach its critical weight.

$$\frac{P_j - P_i}{A_{jk} - A_{ik}} \qquad (7)$$

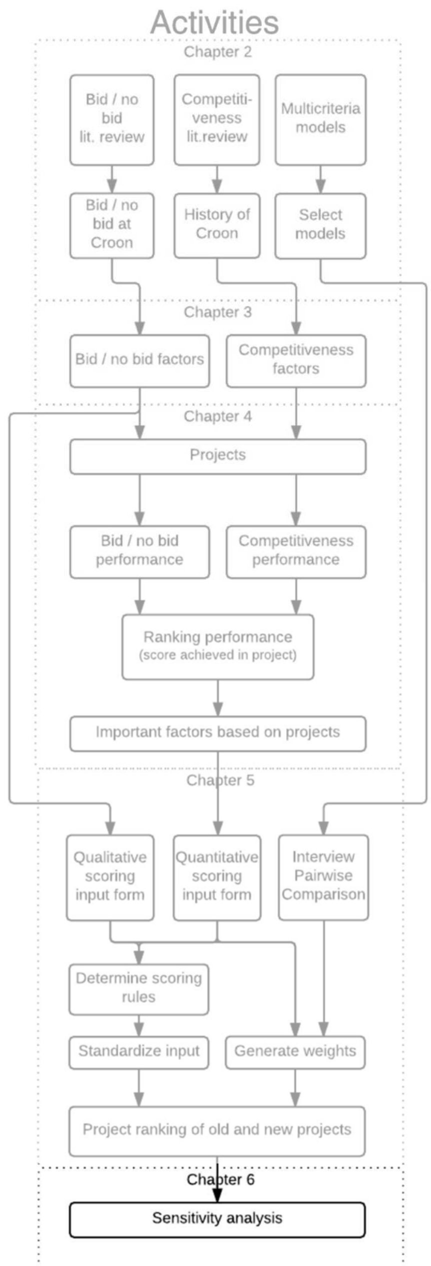


Figure 6.1: Position of chapter six in the research methodology.

6.1. **Applied sensitivity analysis**

Because the method proposed by Triantaphyllou (2000) does not work in this case a number of scenarios will be used to determine sensitivity of the tool. Three methods will be used to determine the sensitivity of the tool.

First three distinct combinations of weights will be used to determine the importance of weighting categories and factors. After this analysis the weight assigned to the quantified factor types is changed to determine the sensitivity of the outcomes to the assumption of 50%/50% weighting. Finally every factor is individually double in weight to determine the sensitivity of the results to the input on one factor.

6.1.1. Four weighting combinations

The first method to determine the sensitivity of the tool is systematically changing the weights of categories and factors. Weights are varied between the weights determined in the Analytical Hierarchy Process or equal weights for categories and factors within categories.

Table 5.15. shows changing category weights has no impact on the ranking, and only little impact on final scores achieved by each project. Changing factors weights leads to rank reversal for multiple projects. This reinforces the use of a weighted tool, especially on factor weights.

	Obtained rank under sensitivity analysis			
	Normal	All equal	Equal category	Equal Factor
Betuweroute MA TTI	5	5	5	5
Maastunnel	2	1	2	1
VIT 2 TTI	1	3	1	2
Gaasperdammerweg	6	6	6	6
Bicycle storage Amsterdam	3	2	3	3
Bicycle storage Maastricht	4	4	4	4

Table 6.1 Changing category and factor weights sensitivity analysis

6.1.2. Quantified type weights

The second sensitivity analysis undertaken is separation and recombination of quantified factors in a distinct category. Since EvaMix normally processes both qualitative and quantitative data a probable weighting scheme is developed and tested to determine the sensitivity of this tool to qualitative inputs.

Table 5.16 shows decreasing the weight of quantitative factors drastically changes the ranking. Furthermore increasing the weight to 80% also leads to rank reversal. It appears the weighting of the quantitative category is of great influence to the results the tool produces. Weights between 50% and 80% produce the most robust results. Care should be taken for overreliance on qualitative factors as these do not encompass all facets of the bid / no bid decision.

	20%	30%	40%	50%	60%	70%	80%
Betuweroute MA TTI	6	6	5	5	5	5	5
Maastunnel	3	3	4	2	2	2	2
VIT 2 TTI	4	4	3	1	1	1	1
Gaasperdammerweg	5	5	6	6	6	6	6
Bicycle storage Amsterdam	1	1	1	3	3	3	4
Bicycle storage Maastricht	2	2	2	4	4	4	3

Table 6.2 Changing factor type weights sensitivity analysis

6.1.3. Doubling one factor weight

The final sensitivity analysis undertaken is doubling the weight the factors one at a time. The remaining weight is divided amongst the remaining factors. An example of this methodology and the weighting set it generates can be seen in table 6.3.

It should be noted the weighting for quantitative and qualitative factors is split into two parts as described in chapter five. The weight displayed are later multiplied with their factor type (quantitative or qualitative), in the interest of readability the weights before this multiplication are used throughout this report.

	Original weights	Partners weight doubled
Partners	2,10%	**4,20%**
Quality of Assets	7,14%	6,98%
Workload	6,72%	6,57%
Specialization	5,46%	5,34%
Knowledge needed	12,59%	12,32%
Contract conditions	17,38%	17,01%
Project finance	10,58%	10,35%
Design & Document quality	6,04%	5,91%
Risk	14,94%	14,62%
Location	3,06%	2,99%
Client type	1,87%	1,83%
Client relations	9,13%	8,93%
Economic conditons	3,00%	2,94%
Experience	48,00%	48,00%
Contract size	7,00%	7,00%
Sustainability	26,00%	26,00%
Contract type	15,00%	15,00%
Succes of competitors	4,00%	4,00%

Table 6.3 Doubling weights sensitivity analysis input weights – Partner factor doubled.

6.1.3.1. Influence of factors

Based on the described methodology table 6.4. was generated. This table shows the success rate as defined in section 5.3. combined with the number of standard deviations the achieved score lies from the average.

The model is sensitive to input on five factors. Knowledge needed and Contract conditions for the quantitative factors lead to a significantly increased or decreased score. Doubling the weights on Experience, Sustainability and Contract type leads to different scores for the quantitative factors.

Nonetheless the model is robust; it provides the same advice for all increased scores; none lead to a “Do not tender” advice. It can be concluded the quantitative factors are particularly influential to the score achieved by the project. The deviating factors are all more than 1,5 standard deviation away from the average.

Increase factor score	**Succes rate**	**Deviation from average in number of σ**
Partners	0,6642	-0,2173
Quality of Assets	0,7182	0,3898
Workload	0,6720	-0,1300
Specialization	0,6393	-0,4971
Knowledge needed	0,8456	1,8222
Contract conditions	0,5678	-1,3012
Project finance	0,6516	-0,3594
Design & Document quality	0,6792	-0,0488
Risk	0,6627	-0,2338
Location	0,6056	-0,8757
client type	0,6364	-0,5300
Client relations	0,7061	0,2534
Economic conditons	0,6363	-0,5307
Experience	0,8361	1,7157
Contract size	0,7258	0,4754
Sustainability	0,5222	-1,8139
Contract type	0,8495	1,8664
Succes of competitors	0,6849	0,0150

Statistics

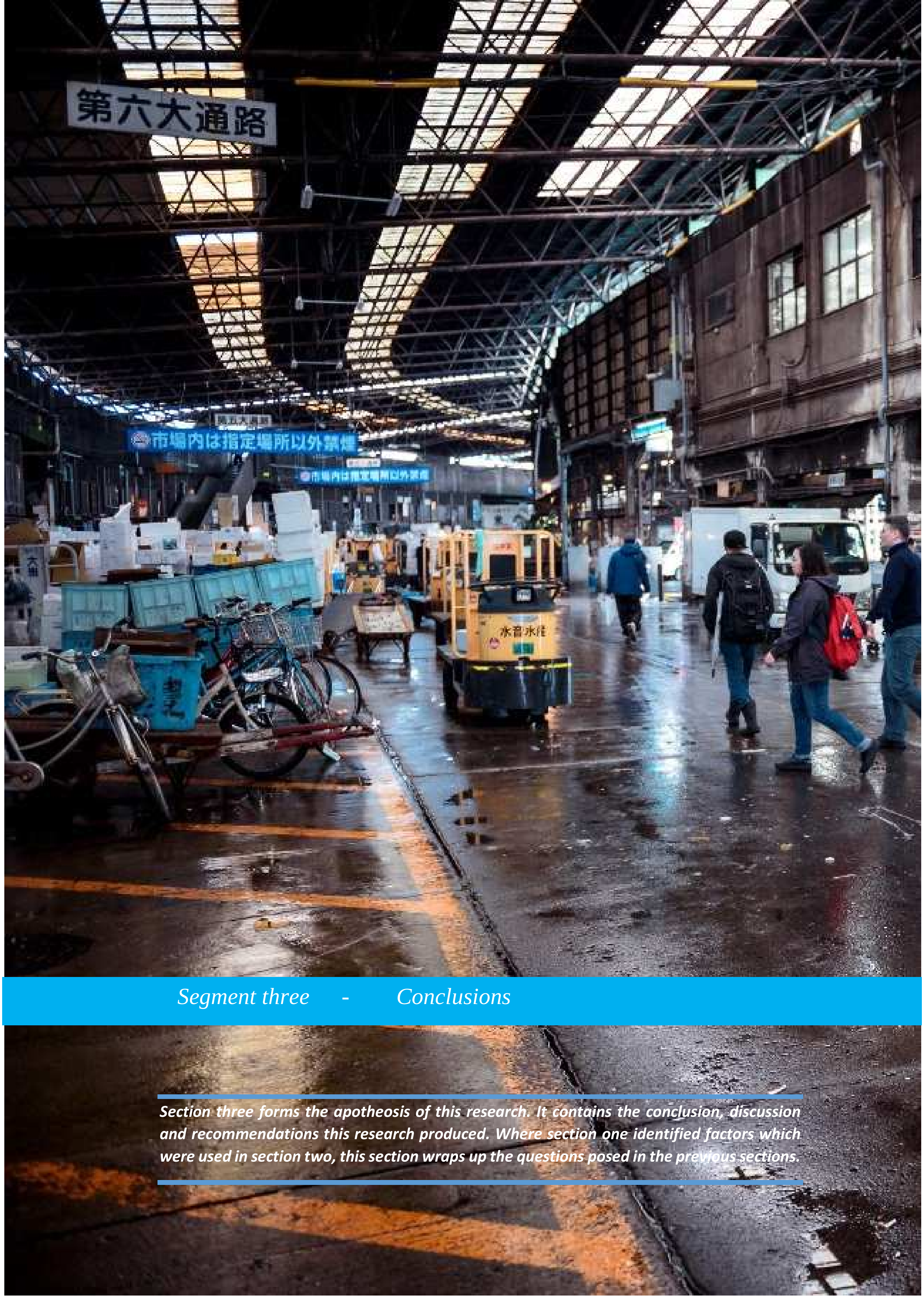
Average	0,6835
σ	0,088936196

Table 6.4 Doubling weights sensitivity analysis results.

6.1.4. Conclusion

Based on the application of three sensitivity analysis methods it can be concluded the tool is robust; especially if weighted categories and factors are used. Weighting quantitative factors increases sensitivity and is possible anywhere in the range between 40% - 80%. Finally five factors show sensitivity to input when their weights are doubled (individually).

Care should be taken for overreliance on qualitative factors as these do not encompass all facets of the bid / no bid decision and sensitivity is greatest for these factors. Therefore selecting a quantitative/qualitative weighting in the lower end of weighting range is recommended. Based on this advice using 50%/50% weighting was a lucky coincidence.



Segment three - Conclusions

Section three forms the apotheosis of this research. It contains the conclusion, discussion and recommendations this research produced. Where section one identified factors which were used in section two, this section wraps up the questions posed in the previous sections.

Figure 7.0: Image on previous page : Deliveries at Tsukiji fish market by N. Hosken (n.d.) retrieved from: http://blog.odigo.travel/wp-content/uploads/2015/11/dsc_4170odigo-tsukiji.jpg

7. Conclusion

To reach the objectives the following research question has been developed: *What bid / no bid and competitiveness factors are the most important for project level competitiveness based on EMAT ranking of large infrastructure projects and how can bid / no bid and competitiveness factors be utilized when making a bid / no bid decision.*

To answer the main research question this research addresses 19 factors both present in bid / no bid literature and competitiveness literate have been identified.

- Partners
- Experience
- Contract size
- Job Type and size
- Risks, Uncertainty & Complexity
- Experience and strength of the firm
- Quality and availability of assets
- Economic conditions
- Competition
- Workload
- Client type
- Location
- Innovations
- Specialization
- Complexity
- Profitability
- Design & Document quality
- Client Financial
- Client Relations

Based on seven case study projects five factors have been isolated that definitely affect project competitiveness for Croon. These factors can be used to improve the bid / no bid decision, basing it on competitiveness. The five factors are:

- Experience
- Sustainability
- Contract size
- Contract type
- Competition

In the bid / no bid decision all factors, including those not found affecting competitiveness, are taken into account to create a robust tool reflecting the complexity of the bid / no bid decision.

The multicriteria method 'Evamix' was selected as the comparison tool to determine the attractiveness of a project. It is most applicable to this decision making problem because it can compare both quantitative and qualitative criteria and creates a ranking of projects whilst remaining relatively transparent to decision makers.

According to decision makers Experience is the most important factor when taking a bid / no bid decision, followed by Quality of Assets, Partners and Innovation. The Analytical Hierachy Process was used to transform the opinions of one decision maker into a set of weights used in a tool.

Combined with the Evidential Reasoning Approach the crucial competitiveness factors are applied to bid/no bid decision making, and combined with bid / no bid factors. Splitting weighting and data input allows for a well-founded weighting using the Analytical Hierarchy Process, whilst ensuring data is standardized and compared without a great burden on decision makers using Evidential Reasoning.

By comparing six projects using the designed tool a ranking can be obtained showing the desirability of projects in comparison to others. Furthermore the tool compares the performance of a project on

In conclusion, twelve factors important bid / no bid decision making and competitiveness have been identified, of which five affect project competitiveness for Croon. A tool has been developed utilizing both these five, and the seven other factors to develop a robust bid / no bid decision making tool. This tool effectively compares both projects and factors to produce a ranking of prefer ability for a selected project.

By integrating an advice and measuring the performance of a project on multiple factors decision makers have more information to make a bid / no bid decision. Implementation of the tool enables contractors to bid on likely successfully tendered projects, reducing the cost of tendering and participating in tenders by discontinuing low probability of winning tenders.

8. Discussion

The main question of this research was: What bid / no bid and competitiveness factors are the most important for project level competitiveness based on EMAT ranking of large infrastructure projects and how can bid / no bid and competitiveness factors be utilized when making a bid / no bid decision.

This is a scientific research because it has led to the coupling of competitiveness to bid / no bid decision making. It relies heavily on data made available by one company, but conclusions can be drawn for the field. Competitiveness factors have been successfully introduced into a quantitative bid / no bid decision making tool. It has been shown the bid / no bid decision can benefit from taking competitiveness factors into account.

The research relies on deductive methods for finding factors, but combining them is an inductive task. More research using for example questionnaires as is custom in bid / no bid literature can improve the replicability of combined factors.

In chapter four factors are analyzed using projects, a limited number of sub factors was used. Using more factors, and basing them completely in literature relevant to the specific factors could lead to different results. Measures used were selected based on the data available decreasing the range of factors available. Furthermore this selection might exclude relevant sub factors. By keeping all factors, even those which have no or negligible effect, in both tools and designing questions based on literature this risk has been mitigated.

The scoring rules for the Evidential Reasoning Approach are based on the data obtained in the case study. This data is the input to inductively determine scoring rules. Removing the inductive approach and instead setting up decision rules can increase replicability of the research.

9. Limitations

A number of limitations exist in this research, they can be broadly grouped into three categories based on the time of enactment of the limitations. These limitations implement constraints on generalizability and reduce the applicability to practice.

The most important limitations are the focus on infrastructure projects won or lost by TBI companies and a focus on projects; the bid / no bid process has not been included. Finally all tenders investigated were finished at the time of research to obtain sufficient information.

Below a short overview of the limitations in this research can be found for each of the three categories.

Starting points

- The tool has been developed for **infrastructure projects**. No knowledge is available about the performance of the tool in other sectors or projects from these sectors. Furthermore the identified factors might not be suitable for other sectors. Other sectors, even when only large projects are investigated, form a large part of the construction market in the Netherlands. Improving the bid / no bid decision for these sectors is a similarly large opportunity to the infrastructure sector.
- The tool has **only been tested for TBI** – and largely Croon. This limits projects to the Netherlands, and leads to unique scoring rules for quantitative factors. All data has been sourced at one company, with a limited amount of work in the Dutch construction industry. It is conceivable different conclusions will be drawn based on other project sets. Furthermore the infrastructure division of the company is young, so institutional knowledge about its competitiveness or the market is limited.
- The bid / no bid **process was not considered** in this research. Therefore there is no advice about implementation of the tool. Nor is there information about the strength and weakness of the bid / no bid process currently employed at Croon and other TBI firms. This also excluded factors during factor identification, narrowing down the scope of the research.
- The selected case study projects were all much larger than the threshold set. Starting at around €20.000.000 the applicability of the tool for low(er) value tenders is unknown. As can be seen in the two Bicycle Storage projects by Mobilis outcomes become more uncertain as the contract value, and thus complexity, risk and other factors, moves away from the average. This might imply winning smaller projects is dependent on other factors than the ones employed in this research.
- To obtain information about tenders it is required for the **tenders** to be **finished**, resulting in (nearly) complete information. At the time of the bid / no bid decision complete information is not a given. Filling in the input form can become a very challenging task, increasing time spent on this task and reducing the usability of the tool.
- **Winning a tender does not mean a project is good or successful**. In this research all won projects are considered “good”. It is possible some won projects are a loss to the company. This has not been taken into account in the design of the tool, nor in the identification of factors and their influence on competitiveness.
- Competitiveness and bid / no bid decision making are immensely complex subject. It is impossible to create a comprehensive, complete and usable model or tool for every contractor. Rather this research is aimed at creating a **comprehensible, usable tool**.

This implies some abstraction are required. This can be seen most clearly in the input for the qualitative data in the Evidential Reasoning Approach; location is scored on a six point scale from positive to negative. Obviously this decision contains a large number of sub factors determining if the input is positive or negative. One can think of travel distance, language, exchange rate etc. Including these sub factors in this tool would make it needlessly complex. This requires exponentially increasing the number of pairwise comparisons that need to be considered and is unfeasible. Furthermore inputting all data would become a time consuming task. Finally the decision maker knows the company best, specifying location into a (large) number of sub factors would not necessarily improve the decision.

Literature and factors

- **Little research into competitiveness** has been done. Even though the number of references to competitiveness in this research is large, every research group focusses on a distinct part of the problem. For example contractor competeviness in China is done by one group, whilst another focusses on developing a nation level framework. There is little cross-referencing between groups; rather research groups references themselves and the pioneering researchers of competeviness. This can be seen best in the network analysis of the competitiveness literary network. No abstract, comprehensive, research exists which completely explains a contractors competitiveness. This made it hard to establish a solid foundation of literature research. That is the reason why this is mostly an explorative research, which could serve as foundation or starting point for future research into this field.
- A **limited number of subfactors** was used to determine competitive performance on projects, and the influence of factors on competitiveness. A more exhaustive test and review of factors could lead to more influential factors, in turn strengthening the quantitative portion of the model.

Tool design and weighting

- **No subfactors were included in the tool**. Adding subfactors would increase the burden of data collection whilst complicating weighting and comparison. Furthermore adding more factors increase the probability of dependency and reduces the impact of distinctive features project have.
- Pairwise comparisons and the AHP are dependent on **input obtained from decision makers**. Obtaining comparisons from multiple decision makers can lead to a “flat” model, where all criteria are weighted the same. Furthermore because no other people were able to provide enough input only one decision maker was used to determine weight, it is possible this has led to skewed weights.

10. Recommendations

Finally some recommendations are in order. The limitations and time constraints have led this research to not completely elaborate on the tool.

The primary recommendation is to add more projects (from other sectors) to the comparison used in the tool. This enriches the comparisons and provides more context for them, leading to a more satisfying result. If this is combined with scoring project based on their performance, rather than win or loss the tool could be much more useful.

The second recommendation is adding more projects to the competitiveness factors research in chapter four. Seven projects from one company is a rather small sample to determine the influence of factors. Coupling this with a method where every sub factor is based in literature increases reproducibility and could enrich the quantitative decision making rules.

Thirdly a better method for determining project competitiveness needs to be developed. The factors identified in this research can provide the starting point for more research into the influence of the identified factors on project competitiveness.

The fourth recommendation is testing the tool on running project in the tendering phase. As described the tool has only been tested and validated on project where tendering is finished. Testing the tool on running projects requires a check on the amount of information available at that stage of the tendering process.

It is also recommended to research the process of tendering, and the position the tool takes within this process. Best practices from other companies and lessons from literature can improve the practices of the entire industry. This in turn could lead to reduces costs of infrastructure and tendering.

Finally a new weighting set needs to be developed based on more opinions, preferably from multi-level decision makers to increase acceptance of the weights used. An additional option would be the development of several weighting sets for different sectors in construction.

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Appendix B - *Bid / no bid forms*

Appendix B.1. - International Projects

Document name Project name Request Date Language	**Bid- no Bid form** **English**	Proposal no. Country Client End user	
Start date **Finish date**			
Commercial Manager Proposal Manager			

Address details

Client	Partner(s)
Name :	Name :
Address :	Adress :
Country :	Country :
Telephone :	Telephone :
Contact person :	Contact person :
Direct phone :	Direct phone :
Position :	Position :
mobile :	mobile :
fax :	fax :
E-mail :	E-mail :

Business	
Client familiar?	YES/NO
If yes, describe.	
Does RFQ suits with the Business plan?	YES/NO
In what way?	
Participation in project as?	Main-contractor/Sub-contractor/Collaboration/Joint Venture
Responsibility level?	Low/Medium/Average/High
Why?	
Nature of project?	Commercial/Military
If military, are their import/export requirements?	
Is governmental financing to be anticipated?	YES/NO
If so, what Country and what format?	
Compensation through Ministry of Economic Affairs?	
Will Croon benefit from this?	

Commercial	
Scope of supply:	Management/Design/Engineering/Detail Design/ Material Supply/Transport/Supervision/Erection/ Commissioning/Maintenance.
Does Croon know project budget?	YES/NO.
If so, what is the Croon share approximately?	
Is it an open tender?	YES/NO
If NO, why are we interested?	
Does Croon have local contacts (advisors/agents/subcontractors)?	YES/NO
If NO, how is Croon able to influence the decision making process?	
Will Croon be able to apply its normal estimating figures for covering overhead, risk and profit?	YES/NO
If NO, what will be applicable?	
Are terms & conditions available at moment of Proposal?	YES/NO
If YES, have they been fully reviewed?	YES/NO
Specific comments to be noted?	
If NO, will General Terms & Conditions Croon be applicable	YES/NO
Specific requirements applicable for this project (QA, Local rules and demands, NEN, Polish specs. etc.)?	

Financial	
Will payments be covered by a bank guarantee/Letter of credit?	YES/NO
If other, please describe	
Payments in Euro?	YES/NO
If other currency, how is exchange risk covered?	
Type of quotation?	(Budget/Lump Sum/Reimbursable)
If Lump Sum, how are price increases covered in case of multi-year program?	
Is (potential) customer financial solid?	YES/NO
If YES, proven by Graydon?	YES/NO
Quotation time frame acceptable?	YES/NO
If NO, extension of time by client accepted?	YES/NO

Technical / Technology	
System description	
In house available technology?	YES/NO
If YES, explain.	
Do we need to design or develop technology not available at Croon?	YES/NO
If YES, how is a solution accomplished?	
If technological development is required with whom will we collaborate?	
Will such collaboration help to reduce our risk?	YES/NO
How?	

Logistics	
Do we have experience with possible suppliers to this project?	YES/NO
Do we feel comfortable with this?	
Explain above given answers:	
Is there sufficient time in proposal preparation process to receive quotes on main equipment?	YES/NO
If NO, are their recent prices available from similar projects?	
If NO, can their extension of time by client be expected?	YES/NO

Capacity	
Is there sufficient capacity available for the execution of the project?	YES/NO
Approved by Business unit manager?	YES/NO

Erection and Installation works	
Erection and Installation works included?	YES/NO
If YES how does Croon arranges its erection crew?	
Do we know a reliable local subcontractor or direct labour supplier?	
How are we going to manage the site erection? (Site manager, supervisor's etc.). Are these in-house or hired-in?	

Political situation etc.	
What is the advice of MinBuZa for this country?	
Do we have experience in this country?	YES/NO
Do we have local agent?	YES/NO
If YES, please state name.	
Do we have positive experience with him?	YES/NO
Taxes, import duties excluded?	YES/NO
If NO, are we familiar with the local Tax system?	YES/NO
Export credit insurance necessary?	YES/NO

General Remarks	
Provide quotation	**YES/NO**

Signed for: Director International Projects A.C. (Aco) v. d. Ven Dated:	Signed for: General Director Croon Elektrotechniek B.V. Dated:

Appendix B.2. - Heavy Industries

Croon Elektrotechniek

Bid/No Bid Formulier Industrie (Binnenland)

1-Algemene Projectinformatie:

Documentnaam :	**Bid/Nobid formulier Industrie**	Proposal/CRM nummer :	
Projectnaam :			
Aanvrager :		Klant/Eindgebruiker :	
Startdatum project:		Opleverdatum :	
Account / Sales Manager :		Tender Manager :	
Aanvraagdatum :		Offertedatum :	
Site Visit datum :			

2-Adresgegevens:

Aanvrager		Klant / Eindgebruiker	
Naam :		Naam :	
Adres :		Adres :	
Postcode en plaats :		Postcode en plaats :	
Contactpersoon :		Contactpersoon :	
Doorkiesnummer :		Doorkiesnummer :	
Functie :		Functie :	
Mobielnummer :		Mobielnummer :	
E-mail adres :		E-mail adres :	

3-Business:

Is klant bekend?	
Bij ja, korte omschrijving?	
Past aanvraag in het BG IND strategischplan?	
In welk opzicht?	
Welke positie nemen wij in, in het project?	
Wat is het aansprakelijkheidsniveau?	
Waarom?	
Aard van het project?	
Bij overheid zijn er speciale vereisten?	
Bij defensie zijn er import en export vereisten?	

4-Financieel:

Moet er bij betalingen een bankgarantie worden overlegd?	
Hoogte bankgarantie	
Als het anders is, gaarne omschrijven?	
Type van de aanbieding / offerte?	
Bij vaste prijs, hoe worden prijsverhogingen bij meerjarige contracten afgedekt?	
Is opdrachtgever financial solvabel?	
Bij ja, is dit onderzocht bij Graydon / Atradius / Cofanet / Dun & Bradstreet?	
Is de offertetijd acceptabel?	
Bij nee, is extra tijd voor de klant acceptabel?	
Betalingscondities	

** bij hoog of > 500K risico formulier invullen

Croon Elektrotechniek | croon TBI techniek

Bid/No Bid Formulier Industrie (Binnenland)	
5-Commercieel:	
Wat is de leveringsomvang:	
Is het Budget van de klant bekend?	
Is het Budget > 500K **	
Bij ja, weten wij wat het Croon aandeel is?	
Is het een open Tender?	
Bij nee, waarom zijn we geïnteresseerd ?	
Hoe is Croon in staat invloed uit te oefenen op het beslissings proces van de klant?	
Is Croon in staat bij gebruikmaking van de normale rekenunits de overhead, winst en risico af te dekken?	
Bij nee, wat is acceptabel?	
Zijn project condities beschikbaar tijdens het offerte traject?	
Bij ja, zijn deze gecontroleerd door Project Management / Legal?	
Is hierover specifiek iets te melden?	
Bij nee, zijn de verkoopvoorwaarden van Croon van toepassing?	
Zijn specifieke voorwaarden voor dit project van toepassing, oa lokale of overheid regels, NEN specificaties etc?	
6-Technisch / Technologisch:	
Systeem Omschrijving	
Is technische personeel bij Croon beschikbaar ?	
Bij nee, aangeven waarom niet.	
Moeten wij een technisch ontwerp maken met personeel wat Croon niet in huis heeft?	
Bij ja, hoe wordt de oplossing bereikt?	
Als een technologische ontwikkeling vereist is, met wie gaan wij dan samenwerken?	
Levert deze samenwerking een lager risico op.	
Zo ja/nee. Hoe & Waarom?	
Moet TTI / TTA / TTP / TCO een basis voorontwerp maken om te kunnen calculeren?	
Bij ja, tot op welk detailniveau is dit vereist, hoeveel uren zijn benodigd voor dit basis ontwerp?	
7-Installatiewerkzaamheden:	
Type project	

** bij high of > 500K risico formulier invullen

Croon Elektrotechniek croon TBI techniek

Bid- No Bid Formulier Industry (Binnenland)	
8-Logistiek:	
Hebben we ervaring met leveranciers voor dit project?	
Verwachte langste levertijd	
Hebben we goede ervaringen met deze leveranciers?	
Verklaar de hierboven gegeven antwoorden	
Is de calculatie tijd voldoende om de leveranciers van de grote bestellingen met elkaar te vergelijken?	
Bij nee, zijn er prijzen van vergelijkbare projecten aanwezig?	
9-Capaciteit:	
Is er voldoende calculatie capaciteit beschikbaar ?	
Maak een inschatting van de calculatieuren	
Is er voldoende capaciteit beschikbaar voor de uitvoering van het project?	
Is er goedkeuring/overlegd van/met de vestigingsmanager?	

Algemene opmerkingen:

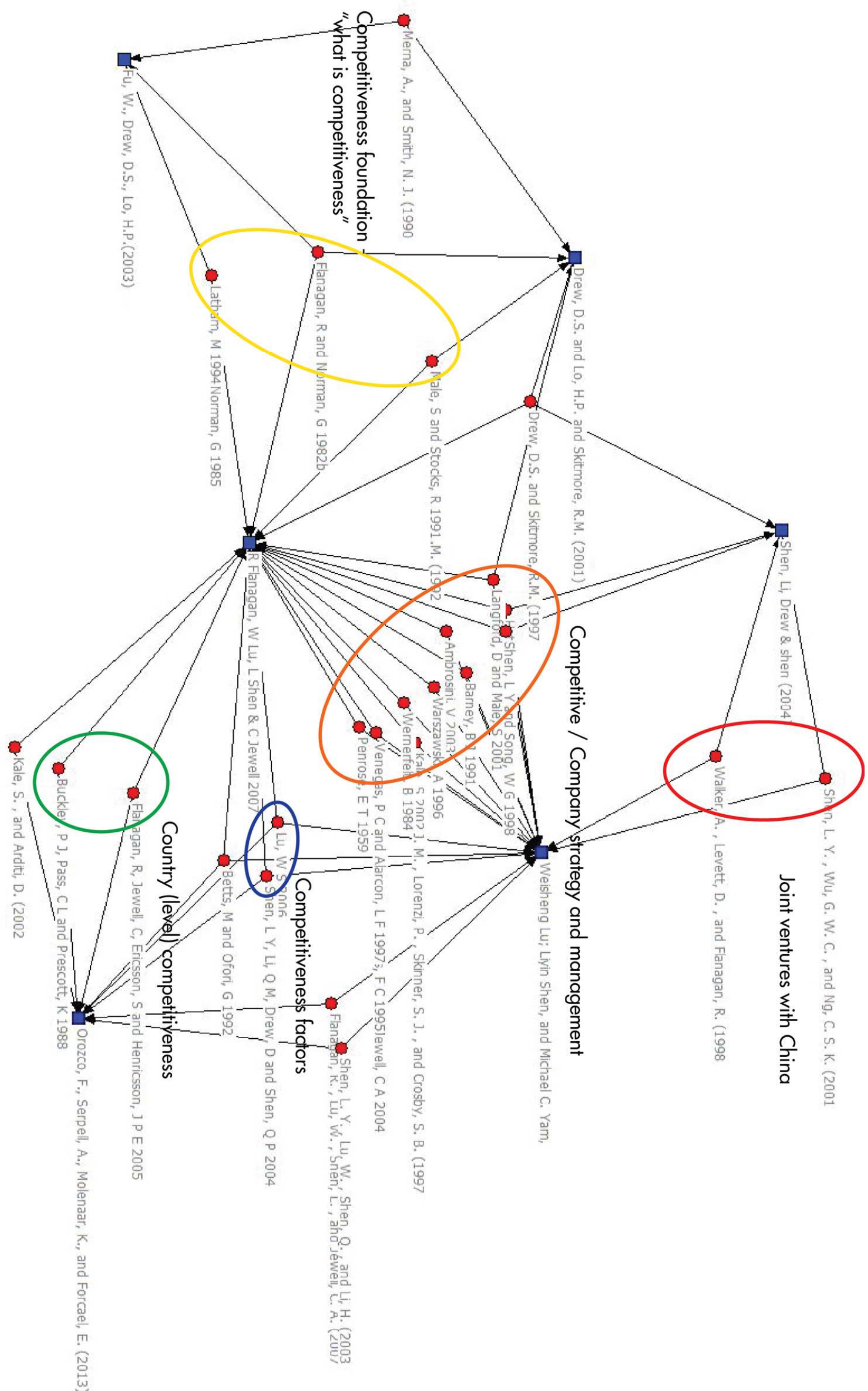
Offerte uitbrengen:	**Ja / Nee**

Ondertekend door:	
BG-Directie	
S.B. (Siebe) van Oosterbaan	
Datum:	

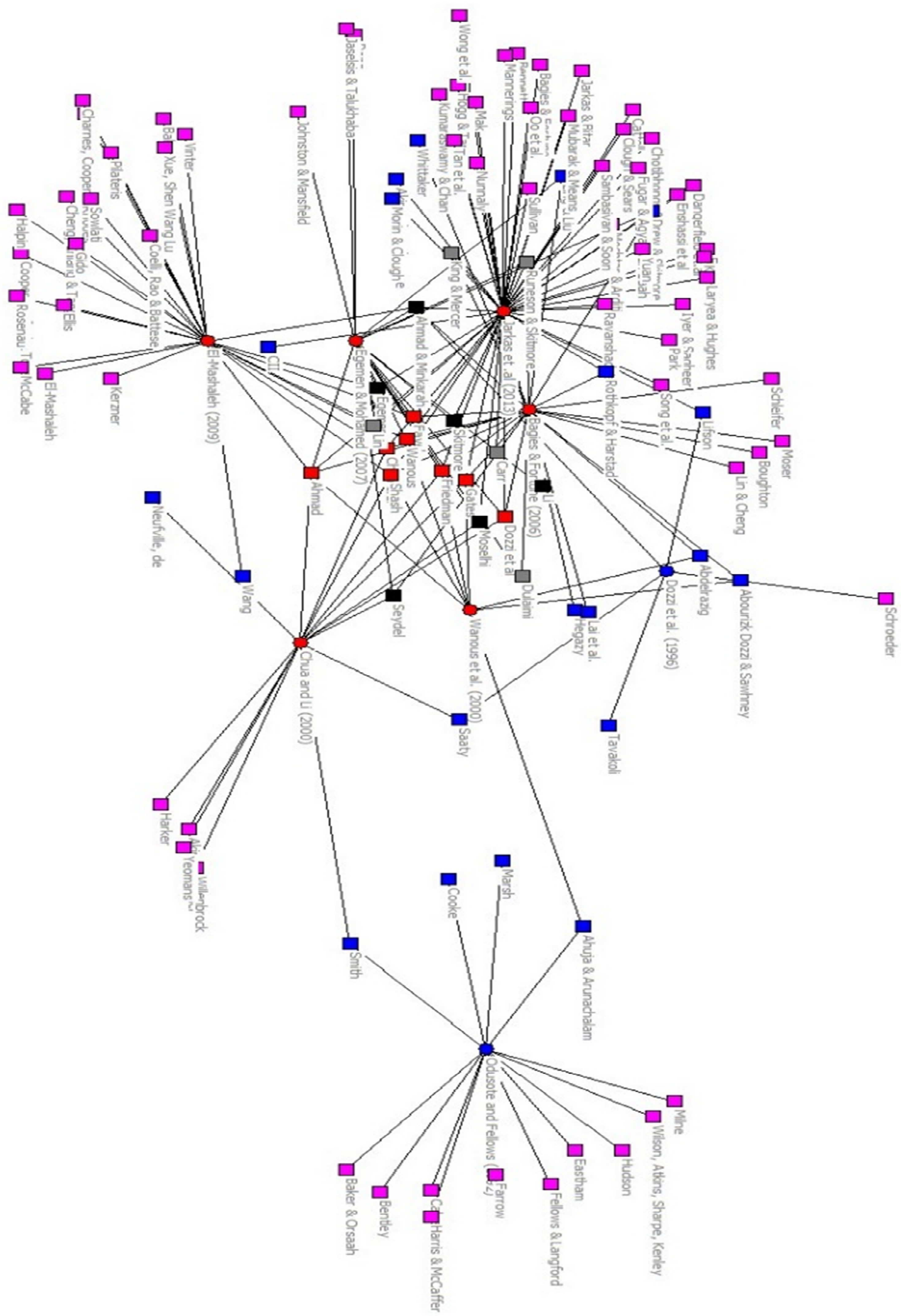
Appendix C - *Factor identification & crosscheck*

Appendix C holds the appendices for chapter three, which deals with identification of factors in both Bid / no bid and competitiveness literature, and a crosscheck between both types of literature.

Appendix C.1. - Competitiveness network graph with "islands" of research



Appendix C.2. - Bid / no bid network graph



Appendix C.3. - Competitiveness network centrality

#	Author	Eigenvector centrality(divided by max possible score)	# of factors identified
33	Betts, M and Ofori, G (1992)	0,202	Competitive strategy and importance
210	Lu, W S (2006)	0,202	
265	Porter, M E (1985)	0,202	Founder of competitive theory
299	Shen, L Y, Li, Q M, Drew, D and Shen, Q P (2004)	0,202	31
192	Langford, D and Male, S (2001)	0,195	Unavailable publication
264	Porter, M E (1980)	0,195	Founder of competitive theory
334	Warszawski, A (1996)	0,195	Context and importance of strategic planning for companies
142	Hatush, Z and Skitmore, M (1997)	0,192	Identified contractor pre-selection criteria
297	Shen, L Y and Song, W G (1998)	0,192	Describes the practice and problems of Chinese tenders
7	Ambrosini, V (2003)	0,183	Unavailable book

Appendix C.4. - Bid / no bid network centrality

#	Author	Eigenvector centrality(divided by max possible score)	# of factors identified
1	Jarkas et .al (2013)	0,732	24
2	Bagies & Fortune (2006)	0,42	Literature review of factors
3	Egemen & Mohamed (2007)	0,379	17
4	El-Mashaleh (2009)	0,269	10
5	Ahmad(1990)	0,257	13
6	Shash(1993)	0,257	28
7	Wanous(2000)	0,231	18
8	Friedman (1956)	0,225	Pioneer of bidding strategy for all industries
9	Ahmad & Minkarah (1988)	0,218	20
10	Chua and Li (2000)	0,216	15
11	Fayek (1996)	0,213	9
12	Dozzi et al	0,207	Uses factors identified by Ahmad & Minkarah, proposes a utility model for evaluating criteria

Appendix C.5. - Bid / no bid factors identified per author

Factors **ranked** at > 60% Overall Relative importance index from (Jarkas et al., 2013)
Previous experience of contractor with employer
Need for work
Current workload
Previous experience in similar projects
Size of project
Identity and reputation of employer in the industry
Financial stability of the employer
Availability of other projects
Promptness of employer in payment process
Tender documents quality level
Qualifications and quality of employer staff
Type of employer
Strength and position of employer in the industry
Availability of required cash
Identity of bidders
Contract conditions
Contract duration
Tendering duration
Complexity level
Availability of equipment required
Payment scheme
Previous profit in similar projects
Number of bidders
Type of project
Employer special requirements
Contract type
Quality of available contractors staff
Location of project

Factors identified by(Egemen & Mohamed, 2007)	
Need for Work	Firm
Strength of firm	
Project conditions contributing to profitability	
Job uncertainty	
Job complexity	
Risk creating job conditions	Project
Client and consultant related risks	
Country economic conditions and instability	
Availability of resources within the country	
Law, Government and regulations	
Competition considering the current projects	
Competition condersidering the current market conditons only	
Foreseeable future market conditions and firm financial situations	Market
Client	
Project	
Consultant firm	
Client expectations	

Factors **identified based on literature review** by El-Mashaleh (2010)
Current workload of project
Financial status of the company
Availability of other projects in the market
Public objection
Technological difficulty of the project being beyond the capability of the firm
Need for continuity in employment of key personnel and workforce
Financial capability of the client
Relationship with the client
Available time for tendering
Site clearance of obstructions

Factors **identified** by (Ahmad, 1990)	
Type	Project
Owner	
Profitability	
Location	
Size	
Degree of Hazard	
Need for work	Firm
Strength of firm	
Economic conditions	Market
Competition	
Supervisory personnel	Resource
Estimators	
Subcontractors	

Factors **identified and ranked** on importance by (Shash, 1993) at importance index >60%
Need for work
Number of competitors tendering
Experience on such projects
Current work load
Owner / promotor client identity
Contract conditions
Project type
Past profit in similar projects
Project size
Tendering method (selective, open)
Risk involved owing to the nature of the work
Project location
Type of contract
Availability of qualified staff
Rate of return
Project cash flow
Tendering durations
Availability of other projects
Availability of labour
Completeness of the documents
Risk involved in the investment
Quality of available labour
Designer / architect / engineer
Anticipated value of liquidated damages
Type and number of supervisory personnel available
Competitiveness of competitors
Contractor involvement in the design phase
Confidence in company workforce
Degree of difficulty

	Factors identified and **ranked** by (Wanous, Boussabaine, & Lewis, 2000)
	Fulfilling the to-tender conditions imposed by the client
	Financial capability of the client
	Relations with and reputation of the client
	Project size
	Availability of time for tendering
	Availability of capital required
	Site clearance of obstructions
	Public objection
	Availability of materials required
	Current work load
	Experience in similar projects
	Availability of equipment required
	Method of construction (manually, mechanically)
	Availability of skilled labour
	Original project duration
	Site accessibility
	Risks expected
	Rigidity of specifications

Factors **identified and ranked** by Ahmad and Minkarah (1988) based on questionnaires with a score of 4 or higher at > 60%.
Type of Job
Need for work
Owner
Historic Profit
Degree of hazard
Location
Labour environment
Strength of the firm
Size of job
Economic conditions
Competition
Risk of investment
Current work load
Degree of difficulty
Rate of return
Confidence in workforce
Uncertainty in estimate
Supervisory persons
Design quality
Reliability of subcontractors

Factors identified and **ranked** by (Chua & Li, 2000)
Need for continuity in employment of key personnel and workforce
Current workload of projects
Relationship with owner
Expertise in management and coordination
Financial ability
Availability of other projects
Similar experience
Require rate of return on investment
Completeness of drawing and specification
Consultants interpretation of the specification
Company ability in required construction technique
Availability of qualified staff

Competence of estimators
Time allowed for bid preparations
Size of project

Factors identified and ranked by (Fayek, 1996) based on questionnaires with a positive response > 60%
Type of Project
Availability of resources and people
Experience
Need for work
Location of the project
Future opportunities with the client
Likelihood of winning the project
Contract value of the project
Strength in the industry

Appendix C.6. - Bid / no bid factor additions per author

	Ahmad & Minkarah (1988)	Ahmad(1990)	Shash (1993)	Fayek (1996)	Wanous et al (2000)	Chua & Li (2000)	egemen & Mohamed (2007)	El Mashaleh (2009)	Jarkas et al (2013)
Project	Type of Job Owner Historic Profit Degree of hazard Location Labour environment Size of job Risk of investment Degree of difficulty Rate of return Uncertainty in estimate Design quality	Profitability	Contract conditions Tendering method (selective, open) Type of contract Tendering durations Completeness of the documents Risk involved in the investment Identity of Designer / architect / engineer Anticipated value of liquidated damages Contractor involvement in the design phase	Contract value of the project	Availability of time for tendering Site clearance of obstructions Public objection Availability of materials required Method of construction (manually, mechanically) Original project duration Site accessibility	Completeness of drawing and specification Consultants interpretation of the specification	profitability conditions Job uncertainty Job complexity Risk creating job conditions Client and consultant related risks	Technological difficulty of the project being beyond the capability of the firm	Tender documents quality level Contract conditions Contract duration Payment scheme Employer special requirements
Firm	Strength of the firm Current work load Confidence in workforce Supervisory persons Reliability of subcontractors Need for work		Number of competitors tendering Experience on such projects Past profit in similar projects Risk involved owing to the nature of the work Availability of qualified staff Availability of labour Quality of available labour Type and number of supervisory personnel available	Availability of resources and people Experience	Fulfilling the to-tender conditions imposed by the client Availability of capital required Availability of equipment required Availability of skilled labour	Need for continuity in employment of key personnel and workforce Current workload of projects Expertise in management and coordination Financial ability Company ability in required construction technique	Strength of firm		
Market	Economic conditions Competition		Availability of other projects Competitiveness of competitors	Likelihood of winning the project Strength in the industry			Competition on current projects Competition current market conditons only Foreseeable future market conditions and firm financial situations Country economic conditions and instability Availability of resources within the country Law, Government and regulations		Identity of bidders Number of bidders
Client			Owner / promotor client identity	Future opportunities with the client	Financial capability of the client Relations with and reputation of the client Rigidity of specifications		Client expectations		Previous experience of contractor with employer Promptness of employer in payment process Type of employer Strength and position of employer in the industry

Appendix C.7. - Competitiveness factor additions per author

L. Y. Shen; Q. M. Li; D. Drew; and Q. P. Shen 2004	Momaya & Selby (1998)	(D. Drew, Skitmore, & Lo, 2001)	Commissie Duivestijn (2002)	Ofori(2003)	(Fu, Drew, & Lo, 2003)	Shen et al. (2004)	Others / Interview	Shen & Tan, unavailable article
Management skill	strategic management, formal planning, implementation,		Risicos te laag ingeschat					
Technical ability	technology, R&D and		Specialisatie	technology; and			Innovation(s)	
Financing ability			Algemene kosten reeds gedekt; lager AKWR Financiele stabiliteit	government's incentives and disincentives.				
Organization structure	productivity, human resources,		Werk voor materiaal en personeel nodig	human resources and their management; communication structures,				Bidder size
Marketing ability	demand conditions and		Het een nieuwkomer op de markt is die zich wil bewijzen Anticipeert op veel meerwerk, dus terugverdienen Veel diverse werkzaamheden Geintegreerd contract	corporate knowledge,		Local market conditions	Identity of partners	
Social influence		Client	Eerder werk van zelfde omvang Gelijke specificities Prestige & markttechnische redenen	track record,	Previous experience in similar projects			
Contribution to project	factor costs, quality/effectiveness, cost,		Efficiency voordeel icm andere werken lijdt tot synergievoordelen Tijd Complexiteit Arbeidsintensiviteit		Degree of standardization o.t. project		Sustainability	

Appendix C.8. - Competitiveness factor description

Below a short description of all competitiveness factors selected can be found.

Appendix C.8.1 Innovation(s) available

The availability of an innovation allows a contractor to distinguish itself from the competition and better satisfy the needs of the customer(Momaya & Selby, 1998). An innovative product allows a contractor to receive a higher quality score, or reduce costs, thereby increasing competitiveness.

- *Innovations create diversification and enables a contractor to distinguish itself.*

Appendix C.8.2 Specialization

Specialists are better able to compete for specialized projects. For example a contractor can be specialized in rush jobs, complex engineering or pile driving. A highly complex job will only have a few competitors for the project(Commissie Duivesteijn, 2004, p. 101).

- *Specialization determines the ability of a contractor to successfully complete a project.*

Appendix C.8.3 Need for work

The need for work or 'work hunger' determines how competitive a contractor is. A 'hungry' contractor does not have enough work on the order book and will be motivated to acquire projects at higher cost. If no projects are won the contractor faces high fixed costs which will not be covered by project which means it is a direct loss to the firm (Commissie Duivesteijn, 2004).

- *Need for work determines the incentive contractors have to decrease prices to pay their workforce.*

Appendix C.8.4 Local market conditions e.g. location

Knowing and understanding local market conditions is imperative for being competitive. A contractor needs to know the number of upcoming jobs and their growth rate, the identity of competitors and their motivation for operating in the market. A new entrant or work hungry competitor might willing to cut prices to get a piece of the market(Commissie Duivesteijn, 2004).

- *Local market conditions determines the attractiveness of the market and expected profitability of a contractor.*

Rather, this research assumes market conditions have not changed in the Netherlands in the past five years. Employment in specialized infrastructure reached the lowest point in 2011 and has been growing slowly since then(Groot, Afrian, Hardeman, & Vrolijk, 2012, p. 88). Revenue for medium to large contractors has been nearly constant since 2011 at around 107% of the 2010 benchmark (Centraal Bureau voor de Statistiek [CBS], 2016).

- Location influences the amount of knowledge about costs, economic conditions, partners and competitors which is available.

Appendix C.8.5 Identity of partners/combination

According to Commissie Duivesteijn (2004) formation of construction consortia is a growing trend in the Netherlands. A temporary partnership for one project is undertaken to share risks, expertise and qualifications such experience on a project of similar size and time. These qualifications are required to undertake a project. By forming a temporary construction consortium a contractor can 'obtain' these qualifications for the next project.

- *The identity of a partner determines the presence of synergy and fraternity which might lead to creation of higher quality products.*

Appendix C.8.6 Client

According to D. Drew et al. (2001) the client has a large influence on competitiveness. Particularly the client type, either public or private sector significantly changes the bidding competitiveness of a contractor. This is believed to be caused by the preference of private sector for large contractors rather than smaller ones(D. Drew et al., 2001).

The larger variety of clients in the private sector, as well as a more selective, invited, bidding procedure is believed to have an influence as well. Furthermore contracts in the private sector are generally more diversified in comparison to those of governments.

Finally public sector clients are bound by competitive tendering legislation which prescribes procedures above thresholds. A private contractor is not bound by these rules and can select its preferred contractor, even if it has a higher price(D. S. Drew & Skitmore, 1992, p. 239).

- *Client type determines the diversity of projects and their procedure.*

Appendix C.8.7 Experience

Experience means contractors have learned from previous projects, through solving problems. Experience increases improvement through repetition of the same task. This is reflected by Fu and Drew (1999) who recognize contractors are twice as competitive when bidding for recurring, similar project types.

According to W. Fu, Drew, and Lo (2003) when citing Ferguson (1989) and Chua and Li (2000) experience enhance competitiveness because contractors obtain knowledge of 'short-cuts' or better methods to economize on construction costs. Furthermore contractors have a better understanding of the characteristics of a project type and can better identify and manage risks, decreasing risks premium.

- *Experience decreases risks premium and increases construction cost economy.*

Appendix C.8.8 Contract type

Contract type usually refers to the reimbursement type of a contract. D. Drew and Skitmore (1997) however defined it as the type of work in their seminal study of competitiveness. They discovered contractors are generally more competitive on a specific contract size, but type of work does play a role.

Care needs to be taken to define what 'types' exist for infrastructure construction. Usually integrated contracts means multiple work types will be included.

- *Contract type determines the type of work included in a contract*

Appendix C.8.9 Contract size, cost and complexity

Another often used criteria to select projects to bid upon is project size. Small local civil engineering firms will not be able to take on the financial and reliability demands for highway project whilst for large firms managing numerous very small projects is cumbersome.

- *Contract size determines the (financial) assets required.*

Appendix C.8.10 Complexity

Project complexity helps determine planning, coordination and control, hinders the clear identification of goals and objectives of major projects. More complex projects require different inputs of expertise and experience requirements of management personnel and greatly affects the project objectives of time, cost and quality.

- *Increased complexity requires a greater expense of planning and experienced managers, and greatly affects time, cost and quality.*

Appendix C.8.11 Process factors not taken into account:

The following process factors were not taken into account.

Category	Factor
Management skills	Strategic management
	Formal planning
	Implementation
	Too low risk evaluation
Financing ability	Financial stability
	Government incentives

Appendix C.9. - Bid / no bid

Below a short description of all bid / no bid factors selected can be found.

Appendix C.9.1 Job Type and Size

Found by Ahmad and Minkarah (1988) to be the most important factor contractors consider when deciding whether to bid is the type of job. A project should be of the type within which a contractor has established knowledge. According to the Centraal Bureau voor de Statistiek (2016) three (general) types of construction work exist;

1. General construction and development i.e. residential and utility buildings;
2. Civil engineering and road construction;
3. Specialised construction i.e. demolition, installation and finishing

Within these categories numerous project opportunities enter the market every year. Another often used criteria to select projects to bid upon is project size. Small local civil engineering firms will not be able to take on the financial and reliability demands for highway project whilst for large firms managing numerous very small projects is cumbersome.

- *Job type determines the sector within which the project is located.*
- *Job size determines the complexity and (financial) assets required.*

Appendix C.9.2 Profitability

Profitability and a required rate of return was first described by Ahmad (1990) and Ahmad and Minkarah (1988). According to Investopedia (2016b) profitability ratios are used to compare the ratio of earnings to costs incurred. Higher profitability makes a project more attractive to bid upon; for similar investments a higher return on capital can be achieved.

- Higher profitability makes a project more attractive to bid upon; for similar investments a higher return on capital can be achieved.

Appendix C.9.3 Risks, Uncertainty & Complexity

Risk, uncertainty and complexity related items are included in almost every central paper. They are closely related factors, as Bosch-Rektveld et al. (2011, p. 730) describe. Bosch-Rektveld et al. understand uncertainty as being the context within which risks can affect the outcome and performance of a project, whilst risk is an important contributor to project complexity. More risks equals a more dynamic project which has more interfaces, making the project more complex.

The bid / no bid literature has not provided a coherent answer to why contractors select risk, uncertainty and complexity as factors contributing to the bid / no bid decision. Egemen and Mohamed (2007) provide the most reasoning when they argue it is more difficult for smaller contractors to deal with complexity, which would make risk, uncertainty and complexity a derivative of size.

Portfolio theory provides another argument for removing risks, uncertainty and complexity; an investor will try to hold a diversified portfolio with a specific risk level(Investopedia, 2016a). Higher risks should lead to higher reward, making risks, uncertainty and complexity a part of profitability.

- *Risk affects the outcome and performance of a project and is a contributor to complexity*

Appendix C.9.4 Location

Location is seen as an important factor by almost all authors, yet none provide an explanation why. It can be argued location is not an independent variable; a number of other factors include elements of location.

Lewis (2002) includes location in multiple categories as a knowledge condition; knowledge about the economic conditions, competitors, partners, client and cost of construction is required for bidding in different locations.

- *Location influences the amount of knowledge about costs, economic conditions, partners and competitors which is available.*

For example a project in a country is closely related to contract specifications and laws particular to the country, and thus location. A project far from the heartlands of the contractor is seen as less desirable because local market conditions and competition are unknown. Location will not be used as a factor for the bid / no bid decision in this research.

Appendix C.9.5 Design & Document quality

Jarkas et al. (2013) view quality of design, tenders and documents as imperative for reducing continuous requests for information and clarifications, and therefore decrease the disruptions to work progress and decreasing project costs. Jarkas et al. also signal Design & Document quality is not solely responsible for a bid / no bid decision but dependant on other factors such as economic condition and current workload. Furthermore it is hard to measure in advance, as well as in retrospect. It will therefore not be used as a factor for the bid / no bid decision in this research.

- *Design and document quality decreases the disruptions to work progress decreases project costs*

Appendix C.9.6 Contract

Contract conditions were first identified by Shash(1993) and are a sporadically returning topic of interest. Wanous et al. and Jarkas et al. broadened the definition of contract type and size to include duration and payment scheme. None of the authors provide a justification why contract conditions matter when making the bid / no bid decision.

One justification is the amount of forward integration present in a project is determined by the contract type. A DBFMO contract will require different skills from a contractor than a simpler Design Bid Build contract. This is closely related to complexity, which was excluded from the list of relevant factors. Where complexity mostly relates to size, contract conditions refer to the type of work. In the previous section type of work was defined as the *sector* within which a project is undertaken{Hombergen, 2016 #1}.

- *Contract conditions define the type(s) of skills a project requires.*

Appendix C.9.7 Experience and strength of the firm

According to Fayek (1996) experience and intuition usually form the basis for the bid / no bid decision. Experience can also include knowledge gained from competing on and building projects however; it increases the knowledge a contractor has about the market situation and the process of bidding and building. The contractor uses this knowledge in setting its price, asserting its dominance in the market and decreasing its cost(W. Fu et al., 2003).

Strength of the firm is closely related to experience. Strength in a particular market segment has been built by gaining experience in specific tasks. Business Dictionary (2016) defines strength as the firm’s capital, knowledge, skill or other advantage it has over competitors in meeting the needs of the customer.

The tasks required can change in the course of time. Contract and market conditions force contractors to develop new strengths, which is signalled by Chua and Li (2000) by identifying “expertise in management and coordination” as one of the critical factors for the bid / no bid decision.

- *Strength is built by gaining experience is specific tasks and is comprised of capital, knowledge, skill or other advantages the firm has over competitors.*

Appendix C.9.8 Quality and availability of assets

Quality and/or availability of assets is mentioned by almost all authors. They mention assets such as labour, skilled staff, equipment and cash. They do not offer an explanation why assets are important however.

Based on interviews some examples are available that illustrate the importance of assets. Vollering (2016) described clients are putting more emphasis on the staff selected for a project. This is reflected by van de Rijt and Santema (2009) who describe interviews are the most important step in selecting a contractor in Best Value Procurement. They state a plan is only as good as the key personnel executing it.

This is echoed by Bayer and Gann (2006) when they describe the ‘rework cycle’; staff availability has an profound effect on project progress. Understaffing and the strategies used to cope with it will affect productivity and quality. There will be pressure to meet deadline, which leads to increased workload and reduced quality.

A similar argument can be made for equipment; a specific type of tunnel required for a project cannot be dug without a tunnel boring machine. If this is not available to the contractor preparing a bid is a futile exercise. Both examples illustrate why availability and quality of assets is important when bidding.

Quality and availability of assets, both man and machine, directly influences workload and expected quality of the product.

Appendix C.9.9 Workload and need for work

According to Kim and Reinschmidt (2006, p. 956) when citing Mayo, contractors change their objective and mark-up decision over time depending on its current workload. Construction is a ‘make to order’ industry, where products are not created and put on the shelf, but rather are made to the demands of a client.

Securing a project gives rise to scheduling, quality and cost problems, because increased workload puts pressure on production facilities(Babu, 1999). Construction firms work with a backlog of projects against demand uncertainty in the market.

Workload is closely related to need for work; in the case of a high need for work the workload is low and contractors are prepared to lower standards with regard to risk and expected return. In times of low need of work and high workload contractors will opt not to bid, or enter a bid with a high risk premium(Chua & Li, 2000).

- *Workload is used to buffer demand uncertainty in the market.*

Appendix C.9.10 Economic conditions

Economic conditions determine the number of project available to the market, and thus to the firm(Ahmad, 1990). In times of project abundance more complex, risky or less profitable projects receive a no-bid (Jarkas et al., 2013). These projects might be accepted in more challenging times.

- *Economic conditions determine the total number of project available to the (domestic) market.*

Appendix C.9.11 Competition

The degree of competition is critical to a contractor's business strategy. It determines the mark-up decision a contractor will make, and thus directly influences the probability of winning a project(Chua & Li, 2000). Knowing the amount of competitors and their identity is critical, as they may have special (technological) advantages or the customer might be biased towards picking a competitor(Lin & Chen, 2004, p. 587).

- *Competition influences the probability of winning a project.*

Appendix C.9.12 Type and identity of client

According to Bageis and Fortune (2009) the type of client, either public or private is of significant importance when making a bid no bid decision. It influences the size, location and risks included in a project. As well as the type of equipment required and the type of contract and contract conditions.

- *Type of client influences the characteristics of the project and the contract.*

Appendix C.9.13 Client relations

General contractors attach a great deal of importance to existing and potential client or owner relationships(Ahmad & Minkarah, 1988). Relations give the contractor knowledge about client demands, previous performance or the existence of a hidden agenda.

Lewis (2002) provides some examples; relations provide knowledge about the operational procedures of the client. Relations enable understanding the business needs of the customer and gives a joined past record which can be either positive or negative.

- *Client relations provide information and knowledge about demands and reliability of the client.*

Appendix C.9.14 Client financial

Client financial is mentioned by a large number of authors as important. Knowing the financial standing and reliability of a client is important when bidding because it provides information about the reliability of (timely) payment.

- *Client finances provide information about reliability of timely payment.*

Appendix D - Competitive influence on projects

Chapter four does not have any appendices associated with it.

Appendix E - Tool design

Appendix E.1. - Questionnaire

Evidential Reasoning Questionnaire

Project :	
Invuller :	

Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.

Toelichting

Experience

What is the difference in experience?	

Sustainability

How much is the estimated bidding freedom available for sustainability in %?	

Contract size

What is the contract value in €?	

Contract type (bidding freedom)

How much is the estimated bidding freedom available in %?	

Contract type (Integration)

What type of contract is the contract? (D&M, DBM, DBFM,DBFMO)	

Success of competitors

What is the success of competitors?	

Partners (Quality)

	Very Bad	Bad	Below Average	Above Average	Good	Very Good
How are <the contractor>'s relations with the partner of this project?						

Workload

	No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons	
Are there reasons to bid low or even take on the work at a marginal price – for example, if it will keep your staff employed or reinforce your position in a particular sector of expertise						

Location

	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive
Is the contract located in a place that is particularly congenial or particularly unpleasant to <the contractor>?						

Client Type

Is the client a single entity or a group of organizations with different responsibilities?	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive

Client Relations(Contacts)

Will the contract bring you useful political or business contacts, enhance your professional standing and raise your profile in the market?	No, not at all	Maybe some	Maybe a few	Yes, definately a few	Yes, some	Yes, many

Client Relations(Understanding)

How well do we understand the business needs of the client?	No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well

Client Relations(Future projects)

Does turning down this project reduce the chance of receiving more invitations from this client?	Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all

Economic conditions

Does this contract open up new markets with good prospects for long term growth?	#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth

Knowledge (challenge)

Will the contract offer a particularly interesting or stimulating professional challenge?	#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging

Quality of Assets (bid manager)

Do we have someone available who can manage the bid effectively?	No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available

Quality of Assets (hire specialists)

	Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all

Do we need to hire specialized staff to undertake this project?						

Risk

How much risk is the contract likely to involve that<the contractor> is unable to accept, manage or transfer to the client?	Very Low	Low	Below Average	Above Average	High	Very High

Project Financial

Is there a risk that winning the contract might strain your financial resources?	#######	Large strain	#######	Some strain	A little strain	No strain at all

Partners (winning)

How important is (scoring) this project to partners?	Not importa nt at all	Not importa nt	#######	Indiffere nt	Importa nt	Very importa nt

Contract conditions (availablity)

Are terms & conditions available at moment of Proposal and how 'special' are they according to legal?	Not available , most likely special	Availabl e, very special	Not available , most likely normal	Availabl e, quite special	#######	Availabl e, normal

Specialization (competencies)

Does <the contractor> have the required competencies or will the contract mean a steep learning curve?	No compete ncies	A few compete ncies	#######	Mostly compete nt	Compet ent	Very compete nt

Specialization (fate of last bid)

How good was the last bid we produced for this type of work? What was its fate?	Not a chance / bid rejected	Lost, below average competit or	Lost, average competit or	Lost, runner up	Won, by a small margin	Won, by a large margin

Profitability

Will <the contractor> be able to apply its normal estimating figures for covering overhead, risk and profit?	No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitabl e project	Yes,very profitabl e projects

Innovations

Do we need to design or develop technology not available at <the contractor>?	No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available

Design and document quality

How good is the design and document quality?	Very Low	Low	Below Average	Above Average	High	Very High

Appendix E.2. - Questionnaire input for VIT 2 TTI, Gaasperdammerweg, Maastunnel and Betuweroute

VIT 2 TTI	Gaasperdammerweg	Betuweroute MA TTI	Maastunnel
Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.	Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.	Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.	Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.
2	-3	0	4
5%	0%	0%	0%
€ 29.000.000,00	€ 340.000.000,00	€ 25.000.000,00	€ 60.000.000,00
25%	40%	150%	21%
D&B	DBFM	D&B	D&B
67%	30%	40%	67%

Very Bad	Bad	Below Average	Above Average	Good	Very Good	Very Bad	Bad	Below Average	Above Average	Good	Very Good	Very Bad	Bad	Below Average	Above Average	Good	Very Good	Very Bad	Bad	Below Average	Above Average	Good	Very Good
				1				1		0				0		0	1					1	

No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons		No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons		No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons		No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons	
	1						1						0	1					1				

Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive
			0,8						0,8						0,8							1	

Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive
		0	1					0	0	1				0	0	1					0,5	0,5	

No, not at all	Maybe some	Maybe a few	Yes, definatelly a few	Yes, some	Yes, many	No, not at all	Maybe some	Maybe a few	Yes, definatelly a few	Yes, some	Yes, many	No, not at all	Maybe some	Maybe a few	Yes, definatelly a few	Yes, some	Yes, many	No, not at all	Maybe some	Maybe a few	Yes, definatelly a few	Yes, some	Yes, many
		1			0			0	1		0		1	0	0		0						1

No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well	No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well	No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well	No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well
			1		0				1		0				1		0						1

Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all	Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all	Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all	Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all
0	0,7			0,3		0	0			0,7		0	0,4			0,5		1					

#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth	#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth	#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth	#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth
				1				0,7		0,3				0		0	1					1	

#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging	#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging	#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging	#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging
			1						0	0,3	0,7				0	0,7	0,3						1

No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available	No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available	No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available	No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available
			1					1	0					1	0								1

Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all	Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all	Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all	Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all
			1				1		0				0	1	0						1		

Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High
		1						0		1				0	1	0		1					

#######	Large strain	#######	Some strain	A little strain	No strain at all	#######	Large strain	#######	Some strain	A little strain	No strain at all	#######	Large strain	#######	Some strain	A little strain	No strain at all	#######	Large strain	#######	Some strain	A little strain	No strain at all
					1				1		0				0	1	0						1

Not important at all	Not important	#######	Indifferent	Important	Very important	Not important at all	Not important	#######	Indifferent	Important	Very important	Not important at all	Not important	#######	Indifferent	Important	Very important	Not important at all	Not important	#######	Indifferent	Important	Very important
	1						0				1		0		1		0						1

Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal	Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal	Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal	Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal
					1				1		0		1		0		0		1				

No competencies	A few competencies	#######	Mostly competent	Competent	Very competent	No competencies	A few competencies	#######	Mostly competent	Competent	Very competent	No competencies	A few competencies	#######	Mostly competent	Competent	Very competent	No competencies	A few competencies	#######	Mostly competent	Competent	Very competent
					1					1	0				0,4	0,6	0						1

Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin	Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin	Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin	Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin
				1	0				1	0	0			1	0	0	0						1

No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable projects	No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable projects	No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable projects	No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable projects
				1						1						1						1	

No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available	No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available	No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available	No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available
				1						1						1						1	

Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High
			1		0				1		0				1		0						1

Appendix E.3. - Questionnaire input for Bicycle storage Amsterdam & Maastricht and Rotterdamsebaan

Fietskelder Maastricht	Fietskelder Amsterdam	Rotterdamsebaan
Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.	Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.	Een score moet niet 100% in één vakje passen; scores mogen ook verdeeld worden. Bij scores die niet optellen tot 1.0 worden overige punten als onzekerheid meegenomen in het model.
0	-1	-2
0%	10%	5%
€ 8.000.000,00	€ 8.200.000,00	€ 301.000.000,00
20%	20%	25%
D&B	D&B	D&B
40%	40%	50%

Very Bad	Bad	Below Average	Above Average	Good	Very Good	Very Bad	Bad	Below Average	Above Average	Good	Very Good	Very Bad	Bad	Below Average	Above Average	Good	Very Good
		0		0	1			0		0	1			1		0	0

No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons		No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons		No Reasons	A few reasons	Some reasons	Many Reasons	Very many reasons	
	0	1					1	0					1	0			

Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive
		1	0					0	0	1					0		1

Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive	Very unattractive	Unattractive	A little unattractive	A little attractive	Attractive	Very attractive
		0	1	0				0	1	0				0	1	0	

No, not at all	Maybe some	Maybe a few	Yes, definately a few	Yes, some	Yes, many	No, not at all	Maybe some	Maybe a few	Yes, definately a few	Yes, some	Yes, many	No, not at all	Maybe some	Maybe a few	Yes, definately a few	Yes, some	Yes, many
0	1	0	0		0	0	0	0	0		1		0	1	0		0

No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well	No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well	No, not at all	No	Maybe no	Maybe yes	Yes	Yes, very well
		0	0	1	0			0	0	1	0				0	1	0

Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all	Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all	Yes, Greatly reduces chance	Yes, slightly reduces chance	#######	#######	No	No, no influence at all
0	0			0	1	0	0			0	1	0	0			1	

#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth	#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth	#######	No market growth	Little market growth	#######	Yes, some market growth	Yes,large market growth
		0		1	0			0		1	0			0,3		0,6	0

#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging	#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging	#######	#######	No, no challenge at all	A little challenging	Challenging	Very challenging
			0	1	0				0	1	0				0	0,3	0,7

No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available	No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available	No, none available	#######	Maybe some available	Yes, some available	#######	Yes,many available
0		0	1			0		0	1					0,5	0,5		

Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all	Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all	Yes, (allmost) all	Yes, a lot	Yes, some	Maybe, a few	#######	No, not at all
	0	0	0,5		0,5		0	0	0,5		0,5		0	0,5	0,5		

Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High
		0	1	0				0	1	0				0	0,3	0,7	

#######	Large strain	#######	Some strain	A little strain	No strain at all	#######	Large strain	#######	Some strain	A little strain	No strain at all	#######	Large strain	#######	Some strain	A little strain	No strain at all
	0		0	0	1		0		0	0	1				0	1	0

Not important at all	Not important	#######	Indifferent	Important	Very important	Not important at all	Not important	#######	Indifferent	Important	Very important	Not important at all	Not important	#######	Indifferent	Important	Very important
	0		0	1	0		0		0	1	0		0		0		1

Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal	Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal	Not available, most likely special	Available, very special	Not available, most likely normal	Available, quite special	#######	Available, normal
	0	0	1		0		0	0	0		1		0		0,4		0,6

No competencies	A few competencies	#######	Mostly competent	Competent	Very competent	No competencies	A few competencies	#######	Mostly competent	Competent	Very competent	No competencies	A few competencies	#######	Mostly competent	Competent	Very competent
			0	1	0				0	1	0				0,2	0,8	0

Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin	Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin	Not a chance / bid rejected	Lost, below average competitor	Lost, average competitor	Lost, runner up	Won, by a small margin	Won, by a large margin
	0	0	1	0	0		0	0	0	1	0			1	0	0	0

No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable projects	No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable project	No, not at all	Most likely not	#######	Yes, narrow margin	Yes, profitable project	Yes,very profitable projects
			1	0					0	0	1					1	

No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available	No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available	No technology available	#######	Some new technology needed, started up	#######	Some technology needed, nearly finished	All technology available
		0		0	1			0		0	1			0,7		0,3	

Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High	Very Low	Low	Below Average	Above Average	High	Very High
		0	0	1	0			0	0	1	0				0	1	0

Appendix E.4. - Evidential scoring rules for quantitative factors

Appendix E.4.1 Contract Size

The average value of the contracts won by Croon is €46.000.000 with a standard deviation of €16.000.000. This is reflected in the scoring rule; the “top” score is €46.000.000 with linear decreasing scores for both higher and lower contract values until the average won or lost value is reached.

Average won value	Standard deviation won	Below average value averaged	Above average value averaged
€46.000.000	€17.000.000	€20.000.000	€391.000.000
Top		Worst	Worst

Table 0.1: Contract size scoring function input.

According to D. Drew and Skitmore (1997) every contractor has a unique price range where it is most competitive. Figure 5.5. is therefore only applicable to Croon. Similar scoring rules for other contractors can be determined using the described methodology.

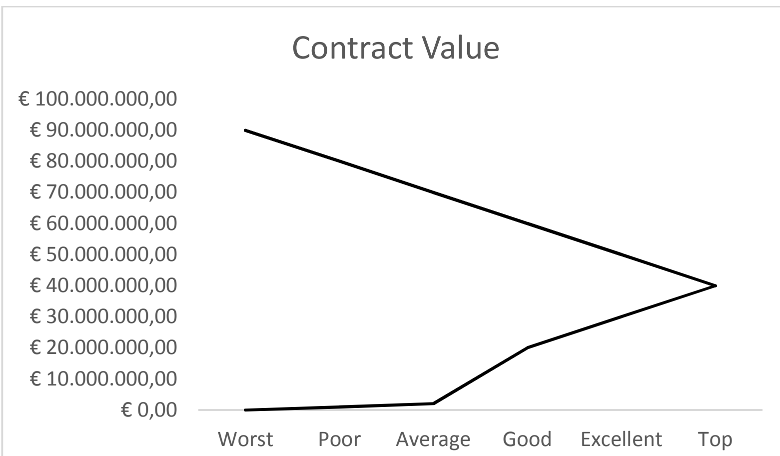


Figure 0.1: The scorings function generated for the Contract value factor.

Appendix E.4.2 Experience

Based on the data more experience leads to a more competitive bid. In the case study projects a difference greater than 0 leads to a more competitive bid. Higher seems to be slightly better. Equivalently, less experience than the competition decreases competiveness. An S-curve around 0, with flat tails for higher experience difference.

It is expected other contractors will have similar curves; a higher difference in experience makes any contractor more specialized and should result in a competitive bid.

Figure 0.2: The scorings function generated for the Experience factor.

Appendix E.4.3 Sustainability

Sustainability of 5% of contract value is the optimal point for Croon. Only one 0% tender was scored. It is assumed more sustainability makes Croon more competitive.

Without data of contracts including more sustainability EMAT no rule can be established beyond 5% therefor linear increasing until 7% is assumed to be best. This results in a function with an emphasis of bad ratings for sustainability smaller than 5% and excellent and top scores for 6% and 7%. Any values larger than 7% are regarded as "top" since Croon appears to score well on contracts with an emphasis on sustainability.

Sustainability curves can differ widely from contractor to contractor. The seven case study projects resulted in a curve with most of scoring around 5%. It is possible other contractors have preferences for a higher or lower degree sustainability bidding freedom.

Figure 0.3: The scorings function generated for the Sustainability factor.

Appendix E.4.4 Contract type – Integration

There is a strong preference for less integrated contracts, with DBM, DBFM and DBFMO being never scored. These score "poor" to "worst" respectively. Other contract forms linearly decrease in preference based on increasing integration. Success rate as shown in table 5.3. is used as a measure for the degree of preference for each contract type.

	Bid	Won	Success rate	Score
D&B	4	3	0,75	Top
DBM	2	0	0	Poor
DBFM	1	0	0	Worst
DBFMO	1	0	0	Worst

Table 0.2: Contract integration scoring function input.

As D. Drew, Skitmore, M., (1997) found contractors were more competitive for specific works such as schools or fire stations it is expected contractors each have a unique preference for contract integration. It is expected the preference of most contractors will be similar to that in figure 5.6.; more contractors are competitive on less complex contracts.

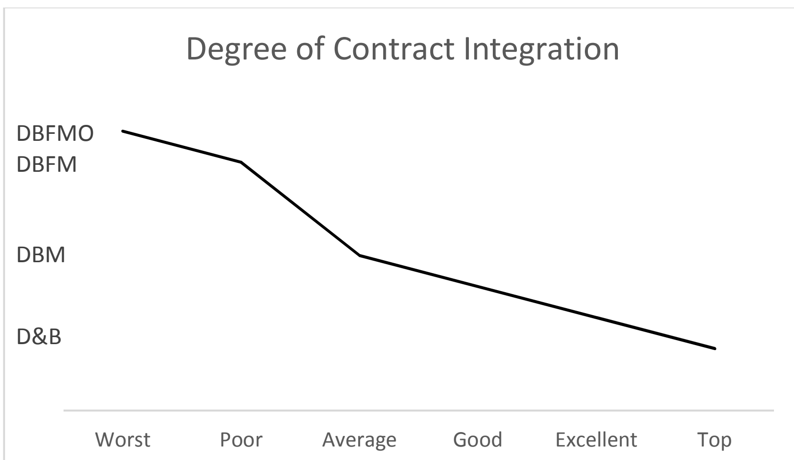


Figure 0.4: The scorings function generated for the Contract integration factor.

Appendix E.4.5 Contract type – Bidding Freedom

Based on the analysis in chapter four lower bidding freedom around 20% is best for Croon. Bidding freedom higher than 40% greatly reduces Croon's competitiveness. This is reflected in the scoring rule for bidding freedom; low values show a high scoring plateau between 20% and 35%, quickly rising as bidding freedom increases.

	Average	Standard deviation	Score
Bidding freedom won contracts	25%	3%	Top
Bidding freedom lost contracts	81%	59%	Worst
Bidding freedom all contracts	57%	51%	

Table 0.3: Bidding freedom scoring function input.

Bidding freedom curves can differ widely from contractor to contractor. The seven case study projects resulted in a curve with good scores up to 30%, beyond 30% Croon lost most of its competitiveness. It is possible other contractors have preferences for a higher or lower degree of bidding freedom.

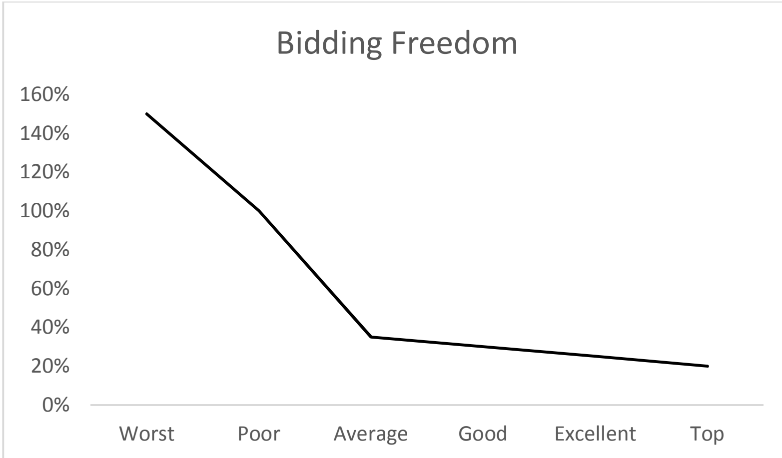


Figure 0.5: The scorings function generated for the Bidding freedom factor.

Appendix E.4.6 Competition - Success of competitors

Success of competitors does not directly influence competitiveness of Croon, but does make bidding more risky. As we have seen in chapter four highly successful competitors seemingly choose the projects they bid on to maximize their competitiveness on those projects.

This leads to a function with very high success competitors scoring worst to poor, similarly very low success competitors are top to excellent. Values around 50% success range in between poor and excellent.

This scoring rule is applicable to all contractors, as highly successful, recurring, competitors decrease the probability of winning a contract.

Figure 0.6: The scorings function generated for the Success of competitors factor.

Appendix E.4.7 Qualitative criteria, Risk and Client Relations

Two types of qualitative criteria and scoring functions can be determined. First qualitative criteria such as risk, where very high risk is undesirable, and equivalently very low risk is desirable. This leads to the scoring function in figure 5.9. with decreasing qualitative attributes corresponding to a higher score.

The opposite of such a function is an increasing function, where a higher quality corresponds to a higher score. An example of such a function is Client Relations. Better relations lead to a higher score.

For both criteria, and other qualitative criteria, no preference information is available therefore a linear scoring function is assumed. The qualitative input changes for every factor however all factors use the six step scale output of the Evidential Reasoning method. In some cases it is not possible to generate rules covering the entire range of qualitative input; for example Contract Integration has only four inputs. The score associated with these limited inputs is unique for each factor.

It is assumed qualitative rules are the same for all contractors based on competitiveness. In the bid / no bid decision other rules can be determined to incorporate for example an attitude with regard to risk.

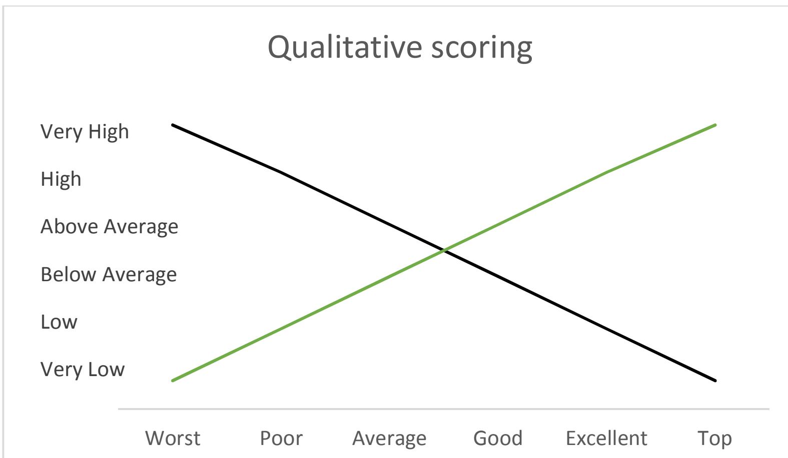


*Figure 0.7: The scorings functions used for the **all** qualitative factors.*

Appendix E.5. - Interviews and decision maker preference

Interviewee 1 - Managing Director

	Risk	Experie nce	Quality of Assets	Need for Work	Compe tition	Innovat ion	Partner s	Contract size
	1	2	3	4	5	6	7	8
1	1	5	0,14285714	0,2	0,2	0,33333333	0,2	0,14285714
2	0,2	1	3	9	5	1	7	5
3	7	0,33333333	1	7	7	0,33333333	5	5
4	5	0,11111111	0,14285714	1	9	1	0,2	0,14285714
5	5	0,2	0,14285714	0,111111111	1	0,2	3	0,33333333
6	3	1	3	1	5	1	5	5
7	5	0,14285714	0,2	5	0,333333333	0,2	1	0,2
8	7	0,2	0,2	7	3	0,2	5	1

n	Criteria	RGMM	Eigenvector
1	Risk	0,035	0,085
2	Experience	0,227	0,210
3	Quality of Assets	0,227	0,193
4	Need for Work	0,059	0,084
5	Competition	0,047	0,056
6	Innovation	0,232	0,171
7	Partners	0,054	0,071
8	Contract size	0,120	0,130

Consistency ratio	0,45

Interviewee 2 - Infrastructure division

	Risk	Experie nce	Quality of Assets	Need for Work	Compe tition	Innovat ion	Partner s	Contract size
	1	2	3	4	5	6	7	8
1	1	1	3	5	3	3	1	7
2	1	1	1	3	1	3	1	7
3	0,33333333	1	1	3	1	3	1	7
4	0,2	0,33333333	0,33333333	1	0,2	0,2	0,2	7
5	0,33333333	1	1	5	1	1	1	7
6	0,33333333	0,33333333	0,33333333	5	1	1	0,33333333	7
7	1	1	1	5	1	3	1	7
8	0,14285714	0,14285714	0,14285714	0,142857143	0,142857143	0,14285714	0,14285714	1

n	Criteria	RGMM	Eigenvector
1	Risk	0,232	0,235
2	Experience	0,165	0,161
3	Quality of Assets	0,144	0,143
4	Need for Work	0,043	0,046
5	Competition	0,134	0,131
6	Innovation	0,089	0,095
7	Partners	0,176	0,171
8	Contract size	0,018	0,018

Consistency ratio	0,05

Interviewee 3 - Heavy Industry division

	Risk 1	Experie nce 2	Quality of Assets 3	Need for Work 4	Compe tition 5	Innovat ion 6	Partner s 7	Contract size 8
1	1	0,2	0,25	4	0,2	0,2	4	5
2	5	1	4	4	0,25	0,2	4	4
3	4	0,25	1	4	4	0,25	0,2	4
4	0,25	0,25	0,25	1	0,25	0,25	0,2	5
5	5	4	0,25	4	1	0,2	0,2	5
6	5	5	4	4	5	1	4	5
7	0,25	0,25	5	5	5	0,25	1	5
8	0,2	0,25	0,25	0,2	0,2	0,2	0,2	1

n	Criteria	RGMM	Eigenvector
1	Risk	0,075	0,089
2	Experience	0,159	0,166
3	Quality of Assets	0,109	0,114
4	Need for Work	0,040	0,030
5	Competition	0,112	0,134
6	Innovation	0,355	0,297
7	Partners	0,126	0,150
8	Contract size	0,024	0,019

Consistency ratio	0,33

Appendix E.6. - AHP weight generation

Appendix E.6. holds the weight generation using AHP for the qualitative factors and categories.

Appendix E.6.1 Categories

n	Criteria	Comment	RGMM
1	Contractor		34%
2	Contract		34%
3	Project		18%
4	Client		11%
5	Economic situation		3%
6			
7			
8			
9		for 9&10 unprotect the input sheets and expand the	
10		question section ("+" in row 66)	

Lennart Koek	1	20-6-2016	α: 0,1	CR: 6%	1
Name	Weight	Date		Consistency Ratio	Scale

		Criteria		more important ?	Scale
i	j	A	B	A or B	(1-9)
1	2	Contractor	Contract	a	1
1	3		Project	a	3
1	4		Client	a	3
1	5		Economic situation	a	7
1	6			b	3
1	7			b	5
1	8			b	7
2	3	Contract	Project	a	3
2	4		Client	a	3
2	5		Economic situation	a	7
2	6			a	1
2	7			a	7
2	8			a	5
3	4	Project	Client	a	3
3	5		Economic situation	a	7
3	6			b	3
3	7			a	5
3	8			a	5
4	5	Client	Economic situation	a	7
4	6			a	1
4	7			b	5
4	8			b	7

A
B

Appendix E.6.2 Contractor category

n	Criteria	Comment	RGMM
1	Experience		22%
2	Partners		7%
3	Quality of Assets		15%
4	Workload		12%
5	Specialization		16%
6	Knowledge needed		29%
7			
8			
9		for 9&10 unprotect the input sheets and expand the	
10		question section ("+" in row 66)	

Name	Weight	Date	α:	CR:	Scale
Lennart Koek	1	20-6-2016	0,1	29%	1

Consistency Ratio

i	j	A	B	more important? A or B	Scale (1-9)		
1	2	Experience	Partners	a	1	2	A3
1	3		Quality of Assets	a	3		
1	4		Workload	a	3		
1	5		Specialization	a	1		
1	6		Knowledge needed	a	1		
1	7			b	5		
1	8			b	7		
2	3	Partners	Quality of Assets	b	1		
2	4		Workload	b	3		
2	5		Specialization	b	7		
2	6		Knowledge needed	b	7		
2	7			a	7		
2	8			a	5		
3	4	Quality of Assets	Workload	a	3		
3	5		Specialization	a	1		
3	6		Knowledge needed	a	1		
3	7			a	5		
3	8			a	5		
4	5	Workload	Specialization	a	5	1	B1
4	6		Knowledge needed	b	7	3	B2
4	7			b	5		
4	8			b	7		
5	6	Specialization	Knowledge needed	b	1		
5	7			a	3		
5	8			b	3		

Appendix E.6.3 Contract category

n	Criteria	Comment	RGMM
1	Contract type		15%
2	Contract conditions		56%
3	Project finance		29%
4			
5			
6			
7			
8			
9		for 9&10 unprotect the input sheets and expand the	
10		question section ("+" in row 66)	

Name	Weight	Date	α:	CR: Consistency Ratio	Scale
Lennart Koek	1	20-6-2016	0,1	45%	1

i	j	A	B	A or B (more important ?)	Scale (1-9)		
1	2	Contract type	Contract conditions	b	7	1	B4
1	3		Project finance	a	1	1	B2
1	4			a	1		
1	5			a	1		
1	6			a	7		
1	7			b	5		
1	8			b	7		
2	3	Contract conditions	Project finance	a	1	1	A2
2	4			a	5		
2	5			a	3		
2	6			a	7		
2	7			a	7		
2	8			a	5		

Appendix E.6.4 Project factors

n	Criteria	Comment	RGMM
1	Contract size		6%
2	Sustainability		36%
3	Risk		48%
4	Location		11%
5			
6			
7			
8			
9		for 9&10 unprotect the input sheets and expand the	
10		question section ("+" in row 66)	

Name	Weight	Date	α:	CR:	Scale
Lennart Koek	1	20-6-2016	0,1	6%	1

Consistency Ratio

A
B

i	j	Criteria A	Criteria B	more important ? A or B	Scale (1-9)
1	2	Contract size	Sustainability	b	5
1	3		Risk	b	7
1	4		Location	b	3
1	5			a	1
1	6			a	7
1	7			b	5
1	8			b	7
2	3	Sustainability	Risk	b	1
2	4		Location	a	3
2	5			a	3
2	6			a	7
2	7			a	7
2	8			a	5
3	4	Risk	Location	a	7
3	5			a	7
3	6			a	9
3	7			a	5
3	8			a	5

Appendix E.6.5 Client category

n	Criteria	Comment	RGMM
1	Client relations		17%
2	Client type		83%
3			
4			
5			
6			
7			
8			
9		for 9&10 unprotect the input sheets and expand the	
10		question section ("+" in row 66)	

Lennart Koek	1	20-6-2016	α:	0,1	CR:	0%	1
Name	Weight	Date			Consistency Ratio		Scale

		Criteria		more important ?	Scale	
i	j	A	B	A or B	(1-9)	A B
1	2	Client relations	Client type	b	5	
1	3			b	7	
1	4			b	3	
1	5			a	1	
1	6			a	7	
1	7			b	5	
1	8			b	7	

Appendix E.6.6 Economic situation category

n	Criteria	Comment	RGMM
1	Economic conditions		17%
2	Competition		83%
3			
4			
5			
6			
7			
8			
9		for 9&10 unprotect the input sheets and expand the	
10		question section ("+" in row 66)	

Lennart Koek	1	20-6-2016	α:	0,1	CR:	0%	1
Name	Weight	Date			Consistency Ratio		Scale

		Criteria		more important ?	Scale	
i	j	A	B	A or B	(1-9)	A B
1	2	Economic conditions	Competition	b	5	
1	3			b	7	
1	4			a	3	
1	5			a	1	
1	6			a	7	
1	7			b	5	
1	8			b	7	

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