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Assessing the influence of tender and project characteristics on project performance

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Management Summary

Annually, [redacted] tenders are made by Tebodin's Tender Management Team (TMT), where in most cases the tender results in a project. Knowledge about the performance on tenders and projects is however lacking. Due to the lack of knowledge, it is unclear what goes well and what goes wrong within the tender and project process, which factors need extra attention and where improvements should take place. As a consequence, it is difficult for the TMT to make right cost estimations and for the management it is hard to steer their teams in a way they stay within project budget. The aim of this study is therefore to assess the influence on tender and project characteristics on Tebodin's project performance. The research question is: *To what extent do tender and project characteristics influence Tebodin's project performance?*

The first step in this study was to identify the tender and project characteristics used at Tebodin and saved in its ERP systems. Next, literature was studied to find out if other studies had discovered a relationship between the tender and project characteristics used at Tebodin and project performance. Based on this literature, hypotheses were formulated. Summarised it was hypothesised that projects in the Netherlands, in mature project management markets, with few disciplines, a small discount ratio, an experienced project manager, cooperative clients and a project without changes will positively influence project performance. In addition, it was hypothesised that type of contract and the producer of the tenders have no influence on project performance.

Preparing the sample, the input for the analysis were [redacted] This time period was used because the [redacted] Although the tender and project data were present in the ERP systems, the projects were not automatically linked to their corresponding tender. So the first step in the data preparation was manually linking the tenders and projects and checking in triple if the links were right. This resulted in a sample of more than [redacted] projects useful for further analysis.

Using multiple regression, evidence was found that the client's main market[1], type of contract[1] and tender manager[1] correlate with project performance, while number of disciplines[1] and project manager[2] have a significant influence on project performance. The regression showed that the [redacted] market performs on average worse compared to the [redacted] market; [redacted] contracts perform on average better than [redacted] contracts and projects tendered by [redacted] perform on average better compared to projects tendered by [redacted]. Project complexity and project ownership were found to be the underlying factors causing these results. Furthermore it was discovered that both the number of disciplines and the experience of a project manager have an influence project performance: the more disciplines the worse the performance and the more experienced the project managers the better the performance. Based on these findings, recommendations were proposed to make better cost estimations and to stay more often within budget: (1) [redacted], (2) [redacted], (3) [redacted] (4) [redacted]. With these actions, better cost estimations can be made because it is known to what extent tender and project variables influence performance. It also gives the management direction on which tender and project variables it should focus to stay within the budget.

This study has some limitations. First, the results cannot be generalised due to (a) non-random sampling: the sample contains [redacted] compared to all Tebodin's projects and (b) the regression model could not be validated, which means that it is unsure if the tender and project characteristics have the same association with project performance in all Tebodin's projects. Second, the hypothesis of the project characteristics client attitude and the number of scope changes during the project could not be tested. During the analysis it turned out that the measures used for these characteristics were insufficient to measure the whole concept. Using these variables would cause validity problems, because the characteristics were not measured in the way they should have been measured to represent the characteristics well.

Finally, this study provides a foundation for future research: (1) [redacted], (2) [redacted] And (3) [redacted]

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[1] With a significance level of 5% [2] With a significance level of 10%

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1. Introduction

In the introduction, a summary of the situation will be given followed by the aim of the research and the corresponding research question. Furthermore, also the scope of the research, safety and compliance, approach, relevance and outline of the thesis will be discussed.

1.1 Situation

The unique character and temporariness of projects make it difficult for organisations to learn from them. Pinto (1999, as mentioned in Turner, Keegan & Crawford, 2004) makes clear that organisations frequently make the same mistakes during projects because they failed to learn from previous successes and failures. A missed opportunity, especially when you consider that 85% of the employees gain knowledge during projects through experiential learning (Turner et al., 2004).

Knowledge can be described as the set of skills, experiences, values and expertise that can be applied to new experiences and information (Davenport & Prusak, 1998; Hanisch, Lindner, Mueller, & Wald, 2009). Companies often try to share the gained knowledge and lessons learned within the organisation. The problem is nevertheless, that in most organisations a structured approach for knowledge sharing is missing. Also pressure of time, due to new projects or other priorities, is a common reason to drop post-project reviews (Von Zedtwitz, 2002). Sharing knowledge within an organisation brings, however, many benefits. Kogut and Zander (1992) write that when knowledge is efficiently passed on within an organisation, a competitive advantage arises. This is supported by Halawi, McCarthy and Aronson (2006) who state even stronger that knowledge is power. Yun, Shin, Kim and Lee (2011) mention at their turn that project performance will increase when knowledge is managed appropriately. As a result of better project performance, corporate success and value creation will grow and the motivation of employees will increase due to better achievements (Mansfield & Odeh, 1991; Cooke-Davies T. , 2002). Thus enough reasons to start sharing knowledge. Knowledge management is "*the set of practices an organisation applies to create, store, use and share knowledge*" (Hanisch et al., 2009, p. 149). Schindler and Gassman (2000) point out that knowledge management does consist of three parts: (1) knowledge within a project, (2) knowledge sharing between projects and (3) knowledge about all executed projects. The third part of knowledge management, the overall knowledge of projects, is missing at Tebodin, the client of this study.

1.2 Tebodin

Tebodin B.V., which stands for Dutch Technical Agency for the Development of Industries, was founded in The Hague, The Netherlands, in the forties of last century. Nowadays, Tebodin B.V. is an international consulting and engineering company active in most of the industrial markets (figure 1). These markets are served by the Tebodin group through its extensive network of around 35 offices in North West Europe, Central Europe, Eastern Europe, Middle East and North America. The projects are executed by 3400 consultants and engineers worldwide, which resulted in an annual turnover of 225 million euros in 2015. Since 2012, Tebodin is part of Bilfinger, an international industrial service provider for the process industry.

The Dutch market plays an important role within Tebodin ever since its foundation. Besides the headquarters, which is located in The Hague, eight other offices are located in The Netherlands. Three of them (Groningen, Hengelo and Deventer) represent the region North East. This region focusses on clients active in food, feed, oil & gas, chemistry and industry markets which are located within North East Netherlands, Germany and Scandinavia. The total workforce of Tebodin North East Netherlands (hereafter Tebodin) consist of around 250 fulltime-equivalent and its contribution to the corporate turnover was million euros in 2015 (Tebodin, 2015).

Figure 1 – One of the engineering projects of Tebodin (HAYS, 2016)

1.3 The problem

Tebodin is a project based organisation. Its main activity is engineering new production facilities or improving existing facilities for her customers. The process within Tebodin for an engineering assignment is shown in figure 2. When a client wants a new production facility or an expansion of a current facility, Tebodin makes a tender for the order. This is also known as the tender process. When the tender is accepted by the client, a project team will be assigned to meet the client's demand. This process is described in more detail in appendix 1.

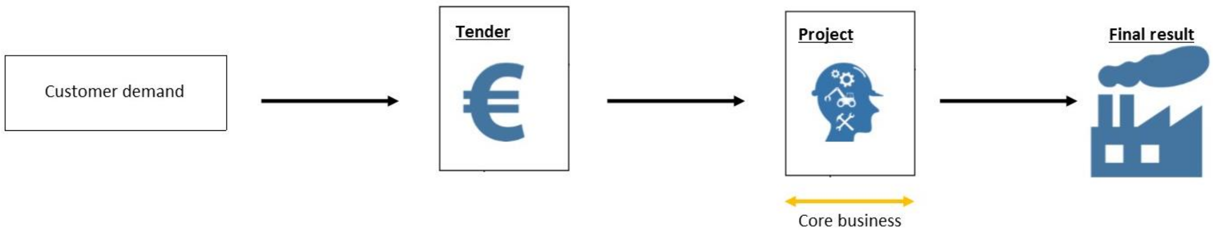

Figure 2 – The process within Tebodin from client demand to a project.

This is the ideal situation: the client accepts the proposal. Yet, it can happen that the estimated costs in the tender are too high by which Tebodin misses the order. In contrast, a cost estimation which is too low results in a low or no profit. Without any knowledge about the performance of preceding projects, it is more difficult to price a tender as keen as possible. In this context, "keen" means as low-priced as possible but also a realistic price, by which the estimated result for Tebodin is attainable in the project phase.

After winning the project a new challenge arises: managing the project within the budget. Also during project it applies that it is more difficult to manage a project to a positive result when it is unknown where in a project it more frequently goes wrong. Knowledge about tender performance and project performance is missing because projects are not quantitatively evaluated on a large scale within Tebodin as shown in figure 3.

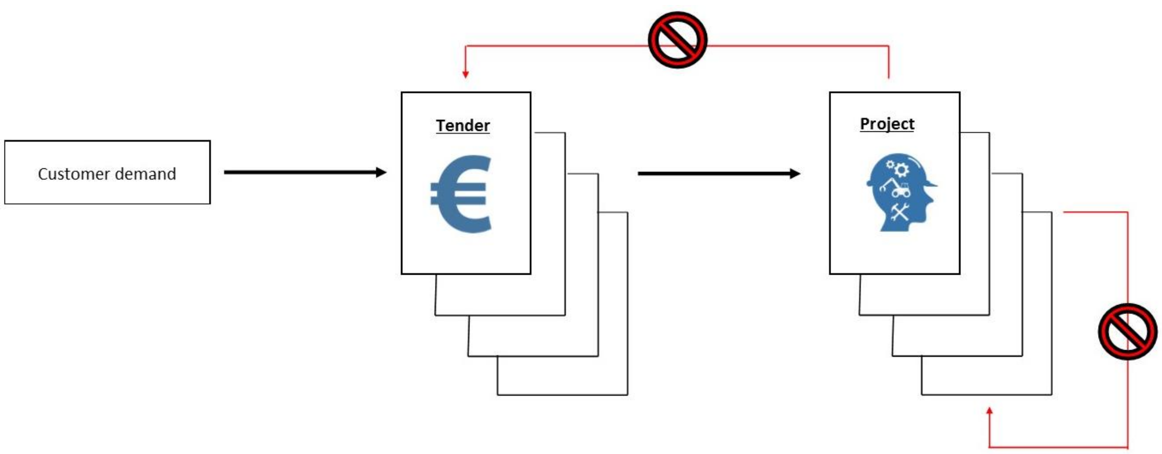

Figure 3 – Within Tebodin, there is no evaluation of the overall projects.

Information about project characteristics and the financial results are gathered and stored in the enterprise resource planning (ERP) systems of Tebodin. So although data about tender and projects is available within Tebodin, it is not used to analyse its performance or used to improve processes. Analysing performance could for example help in making strategic decisions, but it can also be used as a benchmark. Creating a benchmark out of previous performance, it makes it possible to compare the performance over years, between disciplines, between markets, etcetera. With the aid of a benchmark, it becomes possible to price future tenders as realistic as possible and it can be a tool for project managers to improve the realisation of the projects.

1.4 Research goal & question

The main aim of this research is to provide Tebodin insight in its project performance which can serve as input for improving future tenders and projects. This will be done by quantitatively analysing project performance since 2012, from which the data is available in the current databases (ERP systems) of Tebodin, whereupon the data will be translated into management information. This process is visualised by arrow 1 in figure 4. Through the help of the management information, it is possible to improve proposals in terms of cost estimation and projects in terms of cost growth. This process is indicated by arrow 2 in figure 4. A more detailed description of the project approach is given in appendix 2.

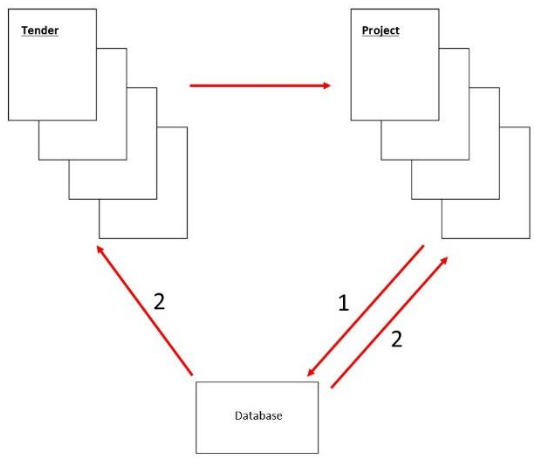

Figure 4 – The aim of the research visually displayed.

The central research question will be:

To what extent do tender and project characteristics influence Tebodin's project performance?

If any association is found between the tender or project variables and project performance, it can help to improve tenders and project management in several ways. For example, when it is found that a certain market performs significant worse in comparison to other markets, a strategic decision could be to stop serving that particular market. For tender management it could imply that a larger risk sticks to that particular market, so more hours or a larger risk fee should be passed on to the tender price. With regard to project management, a more experienced project manager could be assigned to the project for that particular market. In contrast, when it turns out that a particular type of market performs better, it could also have some implications. A strategic decision could be that acquisition should focus more on that market, the tender management team could possible give a larger discount and a less experienced project manager could be allocated to the project. Another example that could be given is client attitude. When it turns there is an association between client attitude and project performance, it can help tender and project management in the future. Regarding tender management, if it is known that a certain client does not easily accept scope changes, an extra risk factor could be passed on to the tender price. It implies for project management that a project manager should be allocated which has proven to manage scope changes well during projects and pays attention to communicating progress with the client. These examples imply that it is useful to analyse the association between the variables and project performance, because it can improve the procedures and performance of Tebodin.

1.5 Scope of the research

[redacted]

1.6 Safety and compliance

Safety and compliance are Tebodin's top priorities. Although the safety risks are limited to traffic safety in this study, compliance plays a greater role. This study is carried out under the supervision of R. Fransen, Tender Manager of Tebodin North East Netherlands. The execution fits within the rules and regulations set by Tebodin and the University of Twente. Confidentiality of business-sensitive information is guaranteed by anonymizing the final report.

1.7 Academic and practical relevance

This study has both academic and practical relevance and has several contributions. First of all, to the best of my knowledge, almost all research regarding project performance is carried out for the construction industry. Because this study is carried out under the authority of an engineering company but similar variables are used which were examined before in other studies, it will be tested whether the industry is a moderator for project performance. Besides, almost no study has a business problem as point of departure. Consequently this study is practically approached and focused on academic problem solving. Third, what makes this study unique, is that it is based on many projects within one firm where almost all studies gather their data through questionnaires across various companies or industry practitioners. Finally, this study can be helpful for companies active in similar markets, struggling with the same problems.

1.8 Outline of the thesis

The structure of the rest of the paper is as follows: chapter 2 explains the theoretical framework of the study, followed by chapter 3 in which the methodology of the paper will be discussed. Chapter 4 discusses the data preparation applied in the research and chapter 5 shows the results. Recommendations for improvements are given in chapter 6 and in chapter 7 the discussion and conclusion are expounded.

2. Theoretical framework

The theoretical framework gives, based on other studies, more insight in the relationship between the tender and project characteristics and project performance. First project performance metrics will be discussed, whereupon the tender and project variables used in this study will be reviewed.

Because this study is commissioned by Tebodin, a practical approach is applied. The variables used in this study to assess their influence on project performance, are variables which are used at Tebodin and saved in its ERP systems. Project location, client market, type of contract, the number of disciplines, the tender manager and the discount given on the cost price are characteristics of the project which return in every Tebodin tender. The same applies for the project manager, the attitude of the client and the scope changes during a project. The aim of the theoretical framework is therefore to find out what kind of relationships other scholars have found between the variables used in this study and project performance. With the help of the findings of the other studies, hypotheses will be formulated for the expected situation within Tebodin. By testing these hypotheses, in one respect this study serves as a conformation of previous studies. On the other hand when the hypotheses are accepted it makes the results of this study more likely. In that case it strengthens the potential recommendations following from this research.

In the following two paragraphs project performance and project complexity will be highlighted. Next, each independent variable and corresponding findings of other studies will be discussed, leading to a hypothesis for the situation within Tebodin.

2.1 Projects and project performance

To consider the project performance, first the meaning of a project must be defined. A project can be described as a temporary goal-driven organisation limited by a certain scope, focussing towards the delivery of a unique product or service (Project Management Institute, 2000; Arthur, DeFillippi, & Jones, 2001; Yu, Flett, & Bowers, 2005). Whether a project is successful or not, depends on the performance success criteria that are used (Ika, 2009). Traditionally, a project is considered successful when it is delivered on time, within budget and to technical specification, whereby it meets client satisfaction (De Wit, 1988; Shenhar, Dvir, & Maltz, 2001; de Carvalho, Patah, & de Souza Bido, 2015). Nowadays project success is more complex. Both De Wit (1988) as Cooke-Davies (2002) argue that a distinction must be made between "*project success*" and "*project management success*". *Project success* is the overall success of the project; a happy customer in spite of project delay can still be considered as a successful project. In *project management success* on the other hand, success is focused on the project process and achieving the cost, time and quality objectives (Baccarini, 1999; Cooke-Davies T. , 2002).

The performance indicator used in this study is cost overrun. The main reason to choose for this performance indicator is that this financial information is present within the company. Besides it has the advantage that using cost overrun is reliable and sound, remains within the realm of the project organisation and matches with the overall objective of the project: making profit (Atkinson, Waterhouse, & Wells, 1997; Shenhar, Levy, & Dvir, 1997). The disadvantage of the use of cost overrun is that it can be misleading: if a project is run within budget, it does not automatically mean that the customer is satisfied.

It has to be kept in mind, that an overrun is not always harmful. [redacted]

2.2 Complexity of the project

Project performance is among others dependent on the complexity of the project. According to Williams (1999; 2005) project complexity consists of two dimensions: structural complexity and uncertainty. Structural complexity is the number of elements in the project and the interdependence between these elements. Uncertainty means the uncertainty in project goals and the methods used in the project. Bosch-Rekveldt, Jongkind, Mooi, Bakker and Verbraeck (2011) add that softer aspects and influences from the environment also play a role in the complexity of a project. Because of this, they describe project complexity as a whole of technological (e.g. scope and tasks), organisational (e.g. size and project team) and environmental (e.g. stakeholders and location) complexities.

Various studies have shown that project complexity influences project performance. It is a broad concept, which can be split into several elements. Bosch-Rekveldt et al. (2011) executed an extensive literature review and found that 40 elements contribute to project complexity. However, in this study only various project and tender variables used at Tebodin and saved within its ERP systems will be used. An overview of the variables used in this study is shown in table 1.

Table 1 – Tender and project variables used in this study

Tender variables	**Project variables**
Location of the project	Project manager
Type of contract	Attitude of the client
Industry	Number of scope changes
Disciplines	
Tender manager	
Cost price vs. selling price	

2.2.1 Location of the project

Especially in the construction industry, the project location is considered as a project characteristic influencing project performance. Several reasons why it can negatively affect project performance: accessibility of the site, the space which is available for temporary facilities, underground utilities, geographical conditions, the weather, basic infrastructure and host country conditions (Dissanayaka & Kumaraswamy, 1999; Kim, Han, & Kim, 2008; Bosch-Rekveldt et al., 2011; Chanmeka, Thomas, Caldas, & Mulva, 2012). Although the factor representing location is questionable (Cronbach's alpha is .577), also the study of Cho et al. (2009) shows that the better the site is accessible, the lower the complexity of the site, the better the project performance will be. Bosch-Rekveldt et al. (2011) discovered that the number of sites and the remoteness of the site are experienced as variables influencing the project performance in the process engineering industry. They also discovered, based on six cases, that the experience in a country has an influence on the project performance. The influence of the country where the project will be constructed is also endorsed by Kim et al. (2008). Matters that must be taken into consideration according to Kim et al. (2008) are difference in culture, language, construction laws and regulation, the extent of corruption and the stability of the country. Opposite to these studies, Creedy, Skitmore and Wong (2010) did not find any relationship between the geographical location within Australia and the cost overrun in highway construction projects.

Although the above mentioned variables have an influence on the project performance in the construction industry, it is questionable if these results can be generalised to the engineering industry. Factors like accessibility of project site for lorries, the spaces for temporary facilities for the construction workers and bad weather conditions, which turned out to have an influence on project performance in the construction industry, does not need to be taken into consideration by an engineer. Factors that must be taken into account by engineers in designing their draft, which were found in the construction industry as having an influence on project performance, are the underground utilities, the geographical conditions and the host country's laws and regulations. The engineers of Tebodin do know what the underground utilities, geographical conditions and law and regulations are in the Netherlands, but they possible do not know this for project locations abroad. When it turns out that the engineer's draft is not in correspondence with the underground utilities, this could lead to a delay in the project by which the project performance decreases. For this reason, there could be a difference in project performance between projects carried out in the Netherlands and the other countries:

Hypothesis 1: Tebodin projects carried out in the Netherlands have a better performance compared to Tebodin projects in other countries.

2.2.2 Industry of the client

The second variable that must be considered while making a tender, is the client's main market. Within Tebodin, a distinction is made between nine markets: oil and gas, chemicals, energy and environment, health and nutrition, infrastructure, industrial, property, public sector and pharma.

Previous research has shown that the maturity of industries regarding project management has an influence on project performance. It was found that the project maturity of the industry correlates with the project risk: the more mature an industry is, the smaller the chances on undesired events which may cause delay, cost overruns, unsatisfactory project results, safety and environmental hazards or project failures (Raz, Shenhar, & Dvir, 2002; Zwikael & Ahn, 2011). This seems logical, because the more experienced the client is with project management, the better the client acknowledges the importance of information sharing and establishing a clear project scope.

Several scholars found different results regarding the project maturity of industries. Ibbs and Kwak (2000) showed that project maturity is the largest in the engineering and construction industry because the project management approach is a common procedure. Cooke-Davies and Arzymanow (2003) state that the petrochemical industry is most mature due to historical reasons. In contrast, the manufacturing industry was identified as the least mature industry due to a lack of competence in schedule development, resource planning, cost control and change control (Grant & Pennypacker, 2006; Project Management Solutions, 2014). The second hypothesis will therefore be:

Hypothesis 2: The more mature the main market of Tebodin's client with respect to project management, the better the project performance will be.

2.2.3 Type of contract

Tebodin mainly offers two types of contracts to its clients: a fixed price contract or a reimbursable contract. Most of the times, the client indicates its preference. Based on scope definition and demand of the customer, the tender managers determine what kind of contract is offered.

Type of contract is mentioned several times in literature as an indicator for project complexity. Traditional contract types within the engineering industry are fixed price contracts and reimbursable contracts. A fixed price contract is a contract where a fixed amount is paid for the full scope of the project. These types of contracts are therefore often used when the scope of the project is clear. A reimbursable contract is a contract at which all the costs directly associated with the work done have to be paid. This type of contract is more obvious when the scope of a project is not fully clear (Meng & Gallagher, 2012; Suprapto, Bakker, Mooi, & Hertogh, 2016). Müller and Turner (2007) interviewed people from eight countries and several industries and discovered that the type of contract was often mentioned as a criteria for complexity. The underlying reason is that every type of contract needs another leadership style of the project manager. Suprato et al. (2016) discuss that fixed price contracts lead to a decrease in client involvement because the scope is already defined. A consequence can be a decrease in information exchange and coordination. Client involvement is in contrast larger at reimbursable contracts, which results in more control and monitoring of the progress and quality. Because this tight involvement can be based on the client's fear that the project manager will maximise its own profit, it is found that the increased cooperation not automatically leads to better results (Müller & Turner, 2005).

The statistical relationship between type of contract and project performance is however not evident. Ling et al. (2004) did not find any relationship between form of contract and project performance in their study to construction projects in Singapore. Remark to this research is that not the type of contract was used as an independent variable, but the contracts between three different companies. Also Suprapto et al. (2016) mention in their study that previous research done by CII (1986) and IPA (2010) did not show any evident relationship between contract type and project performance. They confirmed this result in their own research: no direct relation between the type of contract and project performance was found. Meng and Gallagher (2012) discovered, based on sixty completed questionnaires within the construction industry that fixed price projects are more often managed within budget compared to reimbursable contracts. Because most studies did not find any statistical relationship between type of contract and project performance, the third hypothesis will be:

Hypothesis 3: The type of contract offered by Tebodin will have no influence on project performance

2.2.4 Disciplines

Every tender contains information about the disciplines involved. Not only to give the client an understanding of the work that must be done, but also to make a cost estimation. Within Tebodin, twenty-nine different disciplines can be involved in a project diverse in mechanical engineering to procurement. An overview of all disciplines is given in appendix 3.

Both Baccarini (1996) and Williams (1999) state that the complexity of a project increases when more discipines are involved. According to them, both the structural and technical complexity of the project change as the number of disciplines alter. The structural complexity (the extent to which a discipline cross impacts the design of another discipline) increases as the number of disciplines increases. The same applies to technological complexity (the number of tasks, technologies or teams and the interdependencies between them). This is supported by Bosch-Rekveldt et al. (2011) who also identified that there is a relationship between the dependencies of tasks and project performance. Another study, executed by Ling et al. (2004) tested the relationship between the amount of repetitive elements and cost performance for design-build and design bid-build projects in the construction industry. The results showed that an increase in repetitive elements (and thus less disciplines involved) the better the unit cost would become. It must be taken into account nevertheless that the model indicating this relationship, had a predictive power (R^2) of 0.462 instead of the recommended predictive power of 0.7 or more (Ling, Chan, Chong, & Ee, 2004). Doloi (2012) executed a similar research for the Australian construction industry and found, based on an importance index rendered by 94 responses, that the complexity of the design has an influence on the cost performance. It was mentioned by clients, consultants and contractors as the fourth most important factor influencing cost performance. The fourth hypothesis is therefore:

Hypothesis 4: The fewer disciplines involved in a project of Tebodin, the better the project performance will be

2.2.5 Tender manager

[redacted]

The tender process can be considered as a determining factor in the project performance. Rosenfeld (2013) carried out an extensive root-cause analysis of construction-cost overruns and illustrated that the tender process can have a large influence on the cost performance. Unrealistic low tender-winning price was indicated by 195 respondents as one of the most important causes of a cost overrun. This implies that the experience is essential to make a realistic cost estimation, which is recognised in a research of Laryea (2012). Fong and Chu (2006) add that knowledge sharing within the tender management team positively influences the expertise of a tender manager. It contributes to the improvement of personal capabilities, the quality of work, problem solving capabilities and decision making capabilities of the tender managers.

Although these studies enlighten the importance of experience and expertise in making realistic and successful tenders, no difference is expected between the project performance of tenders produced by tender managers and tenders produced by other employees. On the one hand because the tenders made by other employees are in most cases less complex whereby better cost estimations can be made. On the other hand, the projects tendered by a tender manager are more complex, but they also have more expertise and experience to deal with this level of complexity by which the chance of making unrealistic cost estimations should decrease. Concluding, the fifth hypothesis will be:

Hypothesis 5: The experience of the producer of the tender within Tebodin will have no influence on project performance

2.2.6 Cost price vs. selling price

When the scope is clear, the tender manager asks the engineers of the necessary disciplines to make a time estimation of their work to be done. Based on the estimation of the engineers, the engineering costs of the project can be calculated. On top of that, additional costs will be incurred to cover for example travel expenses. The total cost price of the project will be:

$$Cost\ price = engineering\ costs + additional\ costs + profit\ margin \qquad (1)$$

The project is most of the times sold at a lower price: the selling price. The market price comes about by giving a discount on the cost price. [redacted]

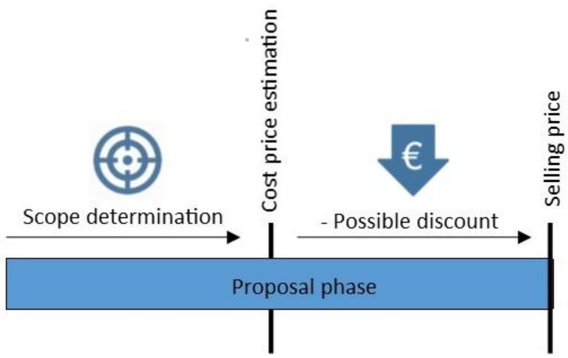

Figure 5 – Process of price arrangements in projects

Several studies, all in the construction industry, looked to the effects of the tender price on the project performance and they show various results. Frimpong, Oluwoye and Crawford (2003) found that a deficiency in the estimate of the costs, leading to a too low tender price, is mentioned as a cause of cost overrun by owners and contractors of construction projects in Ghana. Out of the 26 factors they could choose, a deficiency in cost estimates was ranked at the 10th place. Also the study of Larsen, Shen, Lindhard and Brunoe (2015) showed that this is not the most important factor leading to an overrun. They identified a too low tender price as a cause for cost overruns, although it was ranked at 15th place out of 26 in the relative importance index. Opposite, Rosenfield (2013) discovered that construction managers indicated an unrealistic low tender-winning price as the third cause of cost overrun. Also Fugar and Agyakwah-Baah (2010) found, indicated by owners and contractors in Ghanaian construction industry, a too low tender price as the second most important cause of a decreasing project performance. As mentioned before, all these studies are focused on the construction industry. It is therefore unsure if the results can be generalised to the engineering industry.

Through these findings, it can be supposed that a discount on the cost price can have an influence on the project performance. To maintain the same profit margin, the engineering costs must be reduced. As a result, the engineers have to perform the same job within a shorter time period. When this is not feasible, it is likely that the chance on a cost overrun increases. The next hypothesis will be:

Hypothesis 6: The smaller the discount offered by Tebodin, the better the project performance will be

2.2.7 Project manager

Several studies have shown the influence of the project manager on project performance. Project manager's coordinating and leadership skills (Iyer & Jha, 2005; Enshassi, Mohamed, & Abushaban, 2009) and project manager's leadership style (Müller & Turner, Matching the project manager's leadership style to project type, 2007) are factors examined before. A characteristic of a project manager that is hardly considered as an influencing factor, is the experience of the project manager. Rubin and Seelig (1967) conducted one of the first and only studies to examine the effect of project manager's experience on project performance on R&D projects. They demonstrated that the larger and the higher the priority of the project, the greater the likelihood that a firm will choose for a more experienced project manager. Nevertheless, no direct relationship could be found between the total years of experience of the project manager and the technical performance of the project. Several years later, Schmidt Hunter and Outerbridge (1986) found that job experience leads to betterment of skills which directly improves the performance and increases job knowledge. In both studies, experience is measured in number of years as a project manager, not the overall time within an organisation or overall work experience. Also Ling (2002) discovered that experience in a certain job in the engineering industry has a significant influence on the job performance. This research was however not focused on project managers.

Despite the results of the above mentioned studies differ, it is hypothesised that the more experienced the project manager is, the better the project performance will be.

Hypothesis 7: The more experienced the project manager of Tebodin is, the better the project performance will be.

2.2.8 Attitude of the client

Tebodin has various clients and every client has a different method of working. The experience of the project staff of Tebodin is that they have to deal with both cumbersome, bureaucratic clients and practical, attentive clients. It is supposed that the attitude of the client influences the progress of the project.

Previous studies have shown the influence of the clients on project performance. Dissanayaka and Kumaraswamy (1999) mention that timely decision making of the client had a significant influence on cost overrun in the Hong Kong construction industry. This result was also illustrated by Faridi and El-Sayegh (2006), which identified slowness of decision making of the client as an important cause of project delay in the construction industry of the United Arab Emirates, Lebanon and Saudi Arabia. Also cooperativeness of the client is an important factor for a successful project. Doloi (2012) showed that conflicts and disagreements had a significant influence on cost overrun. Also Chan, Ho and Tam discovered (2001) that a good cooperation between all project parties is the most important contributor to project success in the design-build industry in Hong Kong. Conversely, other studies show less promising results. Enhassi et al. (2009) could not identify the coordination between the client and the project parties as an important factor influencing the performance of construction projects in the Gaza Strip. And also Cho et al. (2009) did not find any statistical relationship between the collaboration of the client and the cost growth of family-housing and road construction projects. Also here the remark has to be made that it is unsure if the results can be generalised to the engineering industry.

Because the experience within Tebodin and the various studies showing a relationship between the attitude of the client and project performance, it is hypothesised that the more the client thinks along with the project team, the better the project performance will be. The eighth hypothesis will therefore be:

Hypothesis 8: The better the cooperativeness of Tebodin's client regarding scope changes, the better the project performance will be.

2.2.9 Changes during the project

Williams (1999) stated that changes during a project do increase project complexity because the structural complexity increases. In line with this statement, several studies found that changes during a project lead to a cost overrun. Kaming et al. (1997) noted that in almost all engineering and building projects a number of changes occur after the contract has started, which inescapably leads to changes in cost schedules. Their research, based on thirty one construction projects in Indonesia, showed that design changes is the dominant variable in influencing cost overrun. Also Assaf and Al-Hejji (2006) observe in their study to different types of construction projects in Saudi Arabia, that out of seventy three causes of time overrun, “changed orders” are in the top ten of most frequent causes of delay and therefore also to a cost overrun (Sambasivan & Soon, 2007). Arantes, da Silva and Ferraira (2015) discovered in their research to the Portuguese construction industry that a changed order was an important cause for delay. Also Aziz (2013) looked at wastewater projects in Egypt and found that additional work was the second most important cause of overruns. All these studies had in common that the data was gathered by questionnaires and analysed by using a Relative Importance Index.

Although most studies in this area are focused on the construction industry, Chang (2002) analysed four engineering projects for roadway construction in California. The results illustrate that all four engineering projects had a cost overrun due to additional work. Although this is the only study focussing on the engineering industry, it can be hypothesised that changes during projects, also called Design Change Notice (DCN) within Tebodin, are positively related to cost overrun. The last hypothesis will therefore be:

Hypothesis 9: The fewer scope changes a project of Tebodin contains, the better the project performance will be.

3. Methodology

This chapter provides information about the steps taken in this research, the research design, the tender and project variables and their selection method, the sample and finally it discusses which technique is used to analyse the data. To keep this chapter as concise as possible, a more detailed clarification about the methodology can be found in appendix 4, 5 and 6.

3.1 Research steps

To answer the research question, several sub questions were formulated. Figure 6 shows how the sub questions were answered by means of the research steps. A more detailed explanation about the steps taken in this process is given in appendix 4.

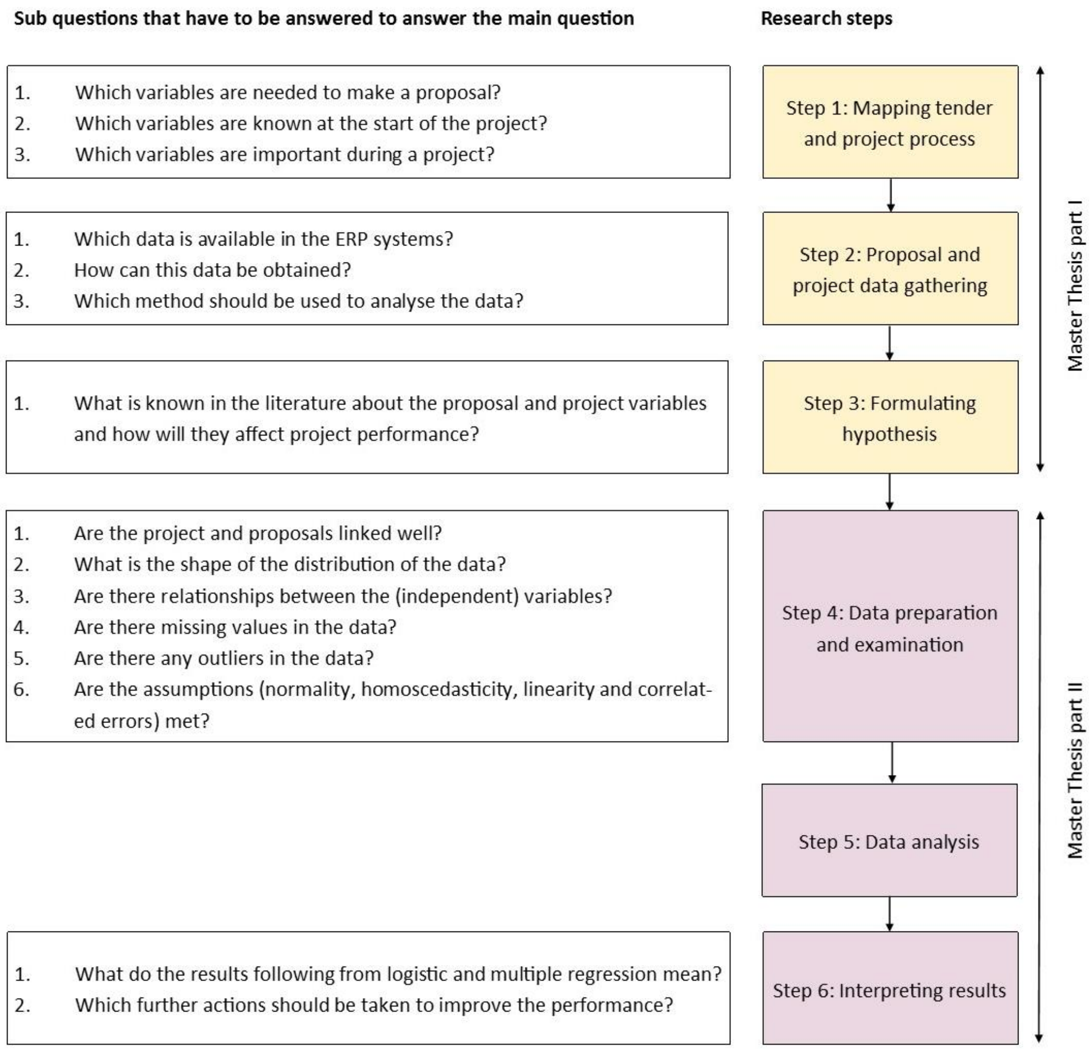

Figure 6 – Overview of the research's sub questions and the corresponding research steps

Because the starting point of this study was a business problem, a practical approach was applied. Because of that reason, the first step was to identify which tender and project variables are used within Tebodin. With the help of conversations with Tebodin employees and analysing the tender and project environment of SharedTools, various variables were identified. The final selection criterion in choosing the variables for this study was the availability of the data within the ERP systems (step 2). The reason of this is that Tebodin preferred a data driven research, because nothing is done with the available project data yet. This led to the research model shown in figure 7.

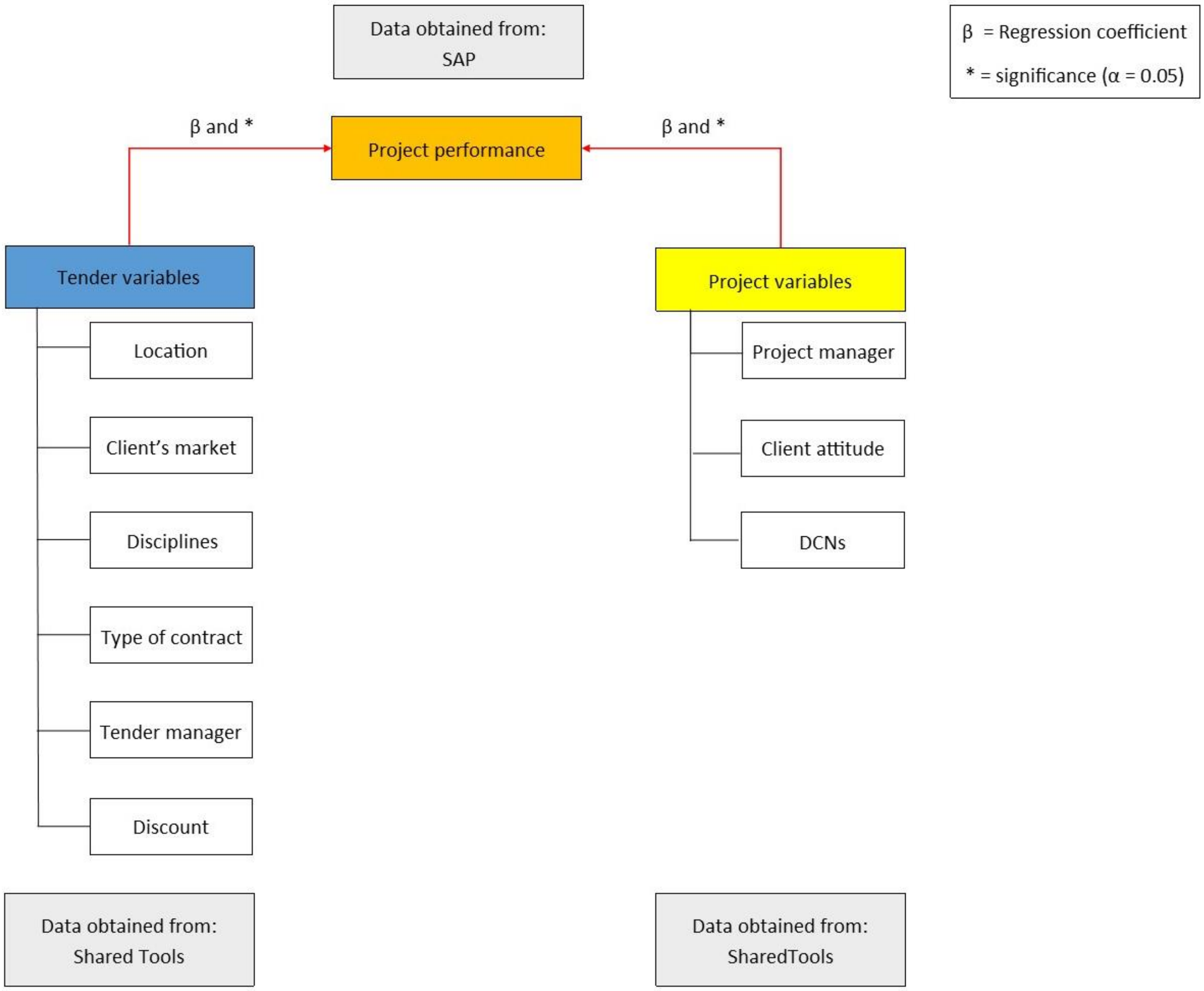

Figure 7 – The variables available in SharedTools and SAP used in this study.

The next step in the research was studying the literature and testing the hypotheses. The aim of the literature study was to discover if other scholars found a relationship between the tender and project variables in this study and project performance. By means of this literature study, hypothesis were formulated aggravated on the situation within Tebodin. Therefore the aim of the hypotheses testing is twofold: on the one hand it is confirming the existent literature about project performance and on the other hand, when the hypothesis can be accepted, it strengthens the potential recommendations following from this study. When a hypothesis must be rejected, it can indicate that other causes underlie project performance or that the industry (engineering in the case of Tebodin) is a moderator for project performance.

In step 4 of figure 6, the data will be prepared and examined for further analysis. The aim of data examination is to discover mutual relationships between variables, identifying missing values or outliers which can have an influence on the regression analyses in step 5 of figure 6. Because the tenders and projects are not automatically linked to each other, linking the projects with their corresponding tender and thereafter checking the correctness of the links will be an important part of the data preparation. Finally, several projects will be filtered out of the sample. This last step is discussed more in detail in paragraph 3.4.

In step 5, logistic and multiple regression will be carried out in order to assess the influence of the tender and project characteristics on the tender success and the project performance. This process is highlighted further in paragraph

3.5. Finally, in the last step of this study, the results of the regression analysis will be interpreted which will result in several recommendations how to improve Tebodin's performance.

As the tender variables were already gathered, an additional analysis was carried out to discover why tenders are lost or won. The model included the same variables as shown in the left part of figure 7, only the dependent variable differed. Instead of project performance, the tender success will be examined. The model for this additional analysis is shown in Figure 8. Appendix 4 discusses the research approach more in detail.

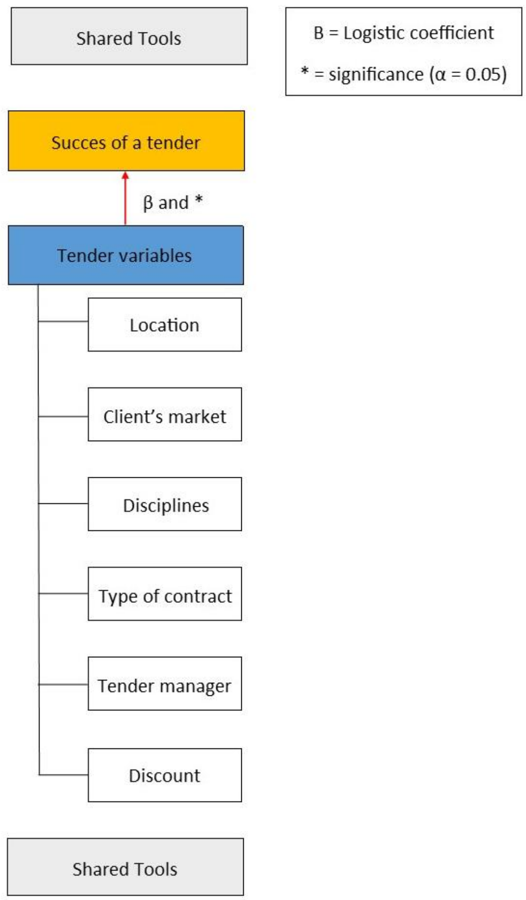

Figure 8 – Variables that will be used to predict the success of a tender based on previous tenders.

As mentioned before, the logistic regression is only a small, additional research. For this reason, no literature was studied to examine if other scholars found a relationship between the tender variables used at Tebodin and the tender success. Because literature study on this domain is lacking, also none hypothesis were formulated.

3.2 Research design

An empirical (hypothesis testing) research was conducted to assess the influence of the tender and project variables on Tebodin's project performance. Due to this approach, a part of the empirical cycle of De Groot (1961) is passed through (figure 9). First, the problem, the research question and the aim of the research were formulated. Next, the tender and project variables within Tebodin were identified whereupon a literature study was conducted. With the aid of literature study, hypotheses were formulated (deduction stage) and tested with the aim of multiple regression (testing). Finally, the results were interpreted and used to formulate recommendations (evaluation).

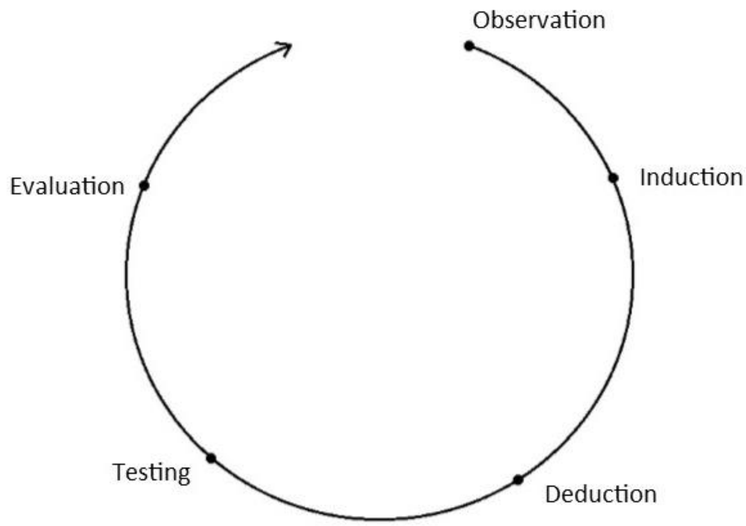

Figure 9 – The empirical cycle of De Groot (Vos, 2017)

3.3 Selection and measurement of the variables

The dependent variable in this research is project performance, which was measured by cost growth in euros. In this context, cost growth is the degree in which the actual costs of the project exceed or stay within the project budget (budget actual). The development of several budgets within a tender and project is shown in figure 10.

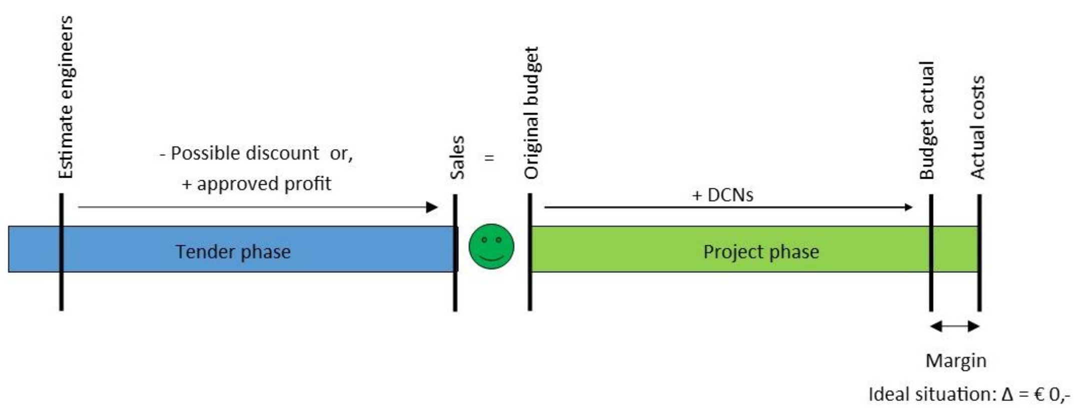

Figure 10 – Overview of the several budgets within a tender and project

[redacted] When the actual costs are smaller than the budget actual, profit is made and in the reverse situation loss will be the result. Table 2 shows the definition of the dependent variable used in this study.

Table 2 – Project performance metrics

No.	Variable	Performance metric	Definition
Y_1	Costs	Cost growth	(Actual costs – budget actual) / Budget actual
Y_2	Success	Tender success	0 = lost, 1 = won

Looking to the formula of cost growth in table 2, it can be observed that a negative cost growth represents a positive project performance, namely a cost underrun. The other way around applies for a positive cost growth, which is cost overrun. The second dependent variable (Y2) in this study was the success of the tenders. Because the result can only be won or lost, this tender success is a binary dependent variable.

The definition of cost growth was based on previous research of Chang (2002), Ling et al. (2004), Cho et al. (2009) and Chanmeka et al. (2012). This definition was chosen because it shows if the project performance is positive or negative and how well the project performs compared to the actual budget. The independent variables used in this study are shown in table 3:

Table 3 – Tender and project characteristic metrics

No.	Project characteristic	Variable	Definition
X_1	Location	Nominal	1 = Netherlands, 2 = other countries
X_2	Client's main market	Nominal	1 = oil and gas, 2 = chemicals, 3 = energy and environment, 4 = health and nutrition, 5 = infrastructure, 6 = industrial, 7 = property, 8 = public sector, 9 = pharma
X_3	Type of contract	Nominal	1 = fixed price, 2 = reimbursable price
X_4	Disciplines	Ratio	Number of disciplines involved
X_5	Tender manager	Nominal	[redacted]
X_6	Discount given	Ratio	Discount ratio: (cost price – sales price) / cost price
X_7	Project manager	Ordinal	[redacted]
X_8	Client's attitude	Ordinal	Client's level of control over design changes: Likert scale from 1 (low level of control) to 5 (high level of control). 1 = very low, 2 = low, 3 = standard, 4 = high, 5 = very high
X_9	Design Change Notice	Ratio	Scope change cost factor: Total costs of scope changes / budget actual

The categories of market, type of contract, tender manager and project manager were not based on any other research, because they were based on the possibilities within Tebodin. The only exception is client attitude, because this is the only variable which was not saved in Tebodin's ERP systems. This variable is however included in the analysis because several stakeholders suggested that this variable plays a role in the performance of a project and besides it is relatively easy for project managers to judge the attitude of the client. The definition of the client's attitude was based on the study of Cho et al. (2009).

Also the definition of the metric variables discount ratio and DCN ratio are based on previous research. The reason to choose for these definitions is that only a discount or the costs of the DCN does make any sense if the original budget is unknown. The definition of discount ratio was based on research of Chang (2002) and the definition of DCN ratio was based on previous research of Chanmeka et al. (2012).

3.4 Sample and data collection

[redacted]

[redacted]

[redacted]

3.5 Data analysis

The aim of the data analysis is to actively assess the influence of the tender and project characteristics on project performance. The regression model shows which variables have a significant influence on project performance, after which can be determined by using the literature study whether there is an association or causation between the independent variables and project performance. When the relationship is examined, it is possible to formulate recommendations how the future performance of tender and projects can be improved.

Multiple regression is a suitable method for this purpose, due to the (metric) character of the dependent variable and the (metric and non-metric) character of the independent variables, multiple regression is a suitable method. However, before the multiple regression could be carried out the data had to be examined first.

Data examination

The first step in the analysis of the data was the examination of the data. First, the data was analysed in a univariate way by which one variable at a time was analysed. With the help of the univariate analyse, first insight into the data is obtained, because it describes the distribution and dispersion of the variables. Also missing values and outliers were identified during this process (Bryman & Bell, 2015). It is important to identify these influential points, because they can influence the result of the multiple regression. After finalising the univariate analysis, bivariate analysis was carried out to discover if two or more variables are related to each other (collinearity), which can affect the results of the multiple regression. When collinearity is present, it is hard to find out if one variable causes an effect or the other (Hair et al., 2010). After completing the bivariate analysis, multivariate analyse could be carried out: the influence of all variables could be tested simultaneously.

Multiple regression

Multiple regression is a quantitative data analysis technique with one metric dependent variable and various metric or non-metric independent variables (Hair et al., 2010). In this research, a confirmatory specification was used for the regression model, because the influence of all variables on project performance had to be measured. To meet the conditions for multiple regression, the categorical variables were converted into dummy variables and the assumptions for multiple regression had to be examined to see if the conditions were met (see appendix 6). By checking the assumptions, it can be ruled out that the errors in the prediction model are the result of latent characteristics in the data. In other words, the prediction is only based on the independent variables. Only when all assumptions are met the multiple regression could be performed (Hair et al, 2010; de Veaux et al., 2016). To facilitate the regression, the Statistical Package for Social Science (SPSS) software was used. Further explanations behind the multiple regression technique can be found in appendix 6.

Association versus causation

As mentioned before, the regression model shows which variables significantly influence project performance, what the magnitude of this influence is and if the influence is positive or negative. If a significant result it found, it can be stated with certainty that there is an association between the independent variable and project performance. However, a significant result does however not automatically imply a causal relationship. Causality demands three conditions, where A is the value of the independent variable and B is the dependent variable: (1) There must be an association between A and B, (2) the A must precede before B, (3) it must be a plausible explanation (Holland, 1986). If one of the above conditions it not met, it is not possible to state that there is a causal relationship between the independent variable and project performance.

Logistic regression

In contrast to linear regression, logistic regression does not predict the value of the dependent variable but it predicts the probability that a tender would be lost or won given the independent variables. The most important assumption in logistic regression is that the dependent variable is a binary variable, which means that it can have two outcomes. Except for the difference in the dependent variable, the logistic regression shows resemblance with multiple regression: the observations are also used to predict the most likely result (Hairet al., 2010; Laerd Statistics, 2015). Likewise as the multiple regression, the logistic regression was also carried out with the SPSS. More information about logistic regression can be found in appendix 6.

The aim of the logistic regression is to assess the assocation between the tender variables and tender success. Because no literature study was applied, no statements can be made about the causality of the tender variables and the tender success. After all, without a literature study it is hard to assess if the independent variable is the only cause of the tender success. For that reason, the logistic regression only shows if the independent variables are associated with the tender success.

4. Data preparation

This chapter elucidates the steps that were taken in the preparation of the data. First the process in which the tenders were linked to their corresponding projects will be discussed.

4.1 Linking the tender and project data

The data for this research is obtained by a printout of the [redacted] (see appendix 5). The dataset contained [redacted]. The linking process consisted of three steps, also shown in figure 11:

1. First, the tenders and projects were linked based on client name and identical project number.
2. Thereafter, the remaining tenders and projects were linked based on client name and resemblance in project title.
3. Finally, the remainder was linked based on similar project number.

Figure 11 – Overview of the results of the linking process between tenders and projects.

A more detailed description of the linking process can be found in appendix 7. All the links were overseen by involved project members within Tebodin as a basic check. [redacted]

[redacted]

[redacted]

Figure 12 – Filtering process of the sample. In sum 339 projects were useful for analysis

After fulfilling the linking process, the data had to be prepared for further analysis. This process is discussed further in detail in appendix 8.

5. Results

This chapter explains the steps taken in the research to examine to what extent tender and project variables do influence the project performance. First, the representativeness of the sample will be examined, followed by an analysis why tenders are lost or won. Next the project performance will be analysed consisting of two parts: the overall project performance and the influence of tender and project variables on cost growth. Like the previous chapter, more detailed information about the results can be found in the appendices to keep this chapter as concise as possible.

5.1 Representativeness of the sample

As mentioned earlier, a total of [redacted] projects were carried out by Tebodin [redacted]

It is important to analyse the representativeness of the sample because otherwise it is not possible to generalise the results of this study to the population. If the sample is not representing the population well, it is uncertain of the same results apply to the population. In this paragraph, only the variables were the sample deviates from the population are discussed. The representativeness of all the variables can be found in appendix 9.

In figure 13, both the population and sample are categorised on magnitude in terms of budget actual. The histograms show how often projects with a certain magnitude occur in the population (left) and sample (right). Comparison of these results makes clear that the sample contains more projects with an actual budget up to €[redacted] and less projects larger than €[redacted] compared to the population. Because the composition of the sample is depended on the linking process, this could imply two things. First, it could imply that tenders with a lower tender price are given more often a project number, by which these projects could be linked more easily. Second, it happens that at the start of the project the original budget changes with respect to the original tender price. So possibly this happens more often for larger projects, by which these projects exceeded the 5% margin of the linking process. This conjecture is supported by figure 14 which shows that [redacted]% of the projects which did exceed the 5% margin and from which the disciplines differed, have an actual budget of €[redacted] or larger. As a result, these projects were filtered out of the sample.

Figure 13 – Distribution of actual budget in the population (left) and in the sample (right)

Figure 14 – The dispersion of budget actual of the 63 projects which did not fulfil the linking requirements.

Besides the actual budget, also some difference in the cost growth appeared. Although the distribution seems to be similar the distribution of the cost growth differs between the sample and population. Although it seems that the cost growth of the population is approximately similar to the distribution of the cost growth in the population (figure 15), the mean and standard deviation differs. The population has a mean value of [redacted] compared to a mean value of [redacted] in the sample. The standard deviation the population numbers [redacted] compared to the standard deviation of [redacted] in the sample (the three highest and smallest values were deleted in the calculation of the mean score and standard deviation). [redacted]

Figure 15 – Distribution of cost growth in population (left) and in the sample (right)

Some differences also appear in tender characteristics type of contract and amount of disciplines. Although figure 16 shows that reimbursable contracts are most common in both the population and the sample, it is visible that the sample contains relatively less reimbursable contracts compared to the population. Another peak is observable in figure 17, where it can be seen that the sample contains relatively more monodisciplinary projects compared to the population. For all other amount of disciplines, the proportion is approximately equal.

Figure 16 – Proportion of type of contract in the population and the sample

Figure 17 – Proportions of amount of disciplines in the population and the sample.

5.1.1 Generalisability

If one of the variables discussed above turns out to be significant, prudence is called for generalising the results to the population because problems with external validity can arise. The comparison between the population and the sample of the variables location (X_1), client main market (X_2), client attitude (X_8) and DCN ratio (X_9) showed a reasonable degree of resemblance as can be seen in appendix 9. Furthermore, it was not possible to examine the representativeness of the independent variables tender manager (X_5), discount ratio (X_6) and project manager (X_7). This was not possible, because the SharedTools printout of the projects did not contain this information. Consequently, for these variables no pronouncements can be made about the generalisation of the results.

5.2 How successful is the tendering process?

In the period from [redacted] until [redacted], [redacted] tenders were made by Tebodin. Figure 18 shows the status of the tenders. As can be seen, [redacted]. Although the tender success seems to be high, it is still interesting to find out why these tenders are won or maybe more important, why tenders are lost.

Figure 18 – An overview of the status of all 2243 tenders.

A logistic regression was applied to determine the probability of winning a tender. Because it is unknown why a tender is cancelled or what will happen with the tenders with the status of hold, submitted or in progress, only the tenders which were won or lost will be used in further analysis. This resulted in an amount of [redacted] which are appropriate for logistic regression.

The initial step in a logistic regression is the examination of the data in order to find mutual relationships and to identify missing values and outliers (Hair et al., 2010). The data examination process is described in detail in appendix 10. As a result of this process, the number of appropriate tenders reduced. [redacted] This could indicate that the producer of the tender estimated the chance to win the tender as low, by which not too much effort was put into the tender. On the other hand, it could imply that the request for the proposal was unclear by which it is more difficult to make a winning tender.

Because the assumptions for logistic regression were met, the regression could be carried out. The aim of the logistic regression was to assess the effects of the six tender variables on the likelihood to win a tender. To assess if the model with independent variables (model 1) is better in predicting the success of a tender compared to a model where the independent variables are not included (baseline model), a chi-square test was performed. Table 4 shows that the chi-square test resulted in a score of [redacted] with [redacted] degrees of freedom (number of independent variables – 1) which results in a p-value < 0.05. So table 4 shows that there is statistical evidence (with $\alpha = 5\%$) to conclude that model 1 is significantly better in predicting tender success compared to the baseline model. To assess how much of the variance in tender success is explained by the model, Nagelkerke R^2 is used (Hair et al., 2010). Table 4 demonstrates that [redacted]% of the variance in winning a tender is explained by the six independent variables. When the tender success would be completely dependent on the six independent variables, Nagelkerke R^2 would have been 100%. So a score of [redacted]% indicates that winning or losing a tender is also subject to other circumstances or characteristics.

Table 4 – Results of the chi-square test comparing the prediction of the baseline model and model 1 relative to tender success.

	Chi-square	df	Sig. (p-value)	Nagelkerke R^2
Model 1	[redacted]	[redacted]	[redacted]	[redacted]
a. Dependent variable: Tender success				

Now that is shown that model 1 is significantly better in predicting tender success, it does not automatically mean that all the tender variables add significantly to the model. With the help of the Wald test, this could be examined. It was found that location, client main market, tender manager and discount ratio are variables which significantly add to the model ($p < 0.05$). This result is shown in table 5. How much these variables influence the odds of winning a tender, is shown in the column with exponentiated B-coefficients. An exponentiated B-coefficient larger than 1 represents an increase in odds, while an exponentiated B-coefficient smaller than 1 represents a decrease in odds of winning a tender. It has to be kept in mind that the categorical variables are measured towards their reference category. With the formula below, the percentage change in odds could be calculated.

$$Percentage\ change\ in\ odds = (Exp.(B) - 1) \times 100\% \qquad (2)$$

As can be seen in table 5, the odds of winning a tender for a project in another country decrease with [redacted]% compared to a project in the Netherlands. With regard to client main market, the odds to win a tender are highest for the clients in the oil and gas market. That the odds for winning a tender are largest for the oil and gas market can be explained by the fact that Tebodin has a framework contract with two clients in the oil and gas market, by which the tender is always won. Going further, the table also shows that the odds for winning a tender increase with [redacted]% [redacted]. Next, it is observable in table 5 that with an increase of each additional discipline, the odds of winning a tender decreases with [redacted]%. With respect to the tender manager, it appears that [redacted]. Finally, the regression shows that the higher the discount ratio the greater the odds of winning a tender. The odds by which the chance to win a tender increases by raising the discount ratio seems to be unlikely and seems to represent infinity. Therefore using the percentage is not reliable. The outcome of discount ratio can probably be explained by the fact that [redacted] Therefore it is likely that the tender will be won.

Table 5 – Overview of the influence of the independent variables in winning or losing a tender.

		B	S.E.	Wald	df	Sig.	Exp(B)	Percentage change in odds
Step 1[a]	Location – Other countries	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Client main market – Oil & Gas (R)							
	Chemicals							
	Energy & Environment							
	Health & Nutrition							
	Industrial							
	Other							

	Type of contract - Reimbursable	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Ln(Disciplines)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Tender manager – Tender manager	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Project manager	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Executives	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Engineers	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Discount ratio	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Constant	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

a. Variable(s) entered on step 1: Location, Client Main Market, Type Contract, Ln(Disciplines), Tender manager, Discount Ratio.

b. Dependent variable: Tender success

The column B-coefficients in table 5 is useful for calculating the probability of winning a tender. With the values of the significant variables, the formula below was made. This formula could help in a bid/no bid decision. If the probability is small, a consideration can be made if the effort is worth the probability (P) of winning the tender.

$$P = \frac{e^{[redacted]}}{e^{[redacted]} + 1} \quad (3)$$

When using this formula, is must be kept in mind that the outcome must be used as an indication. As mentioned before, this model only explains [redacted]% of the variance in the tender success, so also other circumstances or conditions influence the tender success.

5.3 Overall project performance

As mentioned before, [redacted] projects were carried out in the period from [redacted] until [redacted] from which [redacted] projects could be linked with their tender and were therefore useful for further analysis. As mentioned before, six of these projects were left out of analysis because these were internal Tebodin projects and one project was left out of analysis because the cost growth gave an error term. With the remaining sample of [redacted] projects (N = [redacted]), a first impression of Tebodin overall project performance could be obtained.

As can be seen in figure 19, [redacted]

Figure 19 – Proportions of cost underruns and overruns in the sample.

Figure 20 – Sum of Δactual budget – actual costs in euros.

Figure 21 – Overview of the average budget actual and the sum of Δactual costs – budget actual per year

Figure 22 – Dispersion of cost growth in the sample.

Figure 23 and 24 support this suggestion. It is observable in these figures that the cost growth on projects to €[redacted] is better than the cost growth of projects of €[redacted]. Appendix 11 shows the complete development of cost growth when the budget actual increases.

Figure 23 – Dispersion of cost growth of projects with an actual budget to [redacted]

Figure 24 – Dispersion of cost growth of projects with an actual budget of [redacted]

So it can be stated that the larger the project (in terms of actual budget), the more difficult it becomes for Tebodin to achieve a positive performance. When it is assumed that the project complexity increases as the budget actual increases, this is not a strange finding because previous studies already proved that the project performance is dependent on the complexity of the project (Williams T. M., 1999; Williams T. , 2005; Bosch-Rekveldt, & Verbraeck, 2011). In the remaining of this chapter, the variables which possibly influence project complexity of the Tebodin projects will be discussed.

5.4 Influence of tender and project variables on project performance

Of course, the goal of every project manager is to stay within the actual budget of the project. However, in [redacted]% of the projects in the sample [redacted]. To make this proportion smaller, it is interesting to find out which variables influence the cost growth of a project. To figure this out, a multiple regression was run.

Also in multiple regression, the first step is the examination of data (Hair et al., 2010). [redacted] The sample size has a strong influence on (1) the statistical power of the multiple regression and (2) the generalizability of the results. The statistical power is the probability that the significant relationship that is found truly exists. Using too small samples decreases the power, while too large samples make the statistical relationship hypersensitive. The statistical power is dependent on the sample size and the number of independent variables: the larger the number of independent variables, the larger the sample size must be to maintain the statistical power. With regard to the generalizability, at least five observations are necessary for each independent variable. With [redacted] observations ([redacted] / [redacted] independent variables) per independent variable this requirement is met. However to be sure the results are generalizable, the advisable level of observations is 15 to 20 for each independent variable (Hair et al., 2010). A more detailed description of the data examination process and the multiple regression can be found in appendix 12.

After data examination, the assumptions for multiple regression were tested and met: homoscedasticity and linearity were examined by a plot of studentised residuals against predicted values, independence of residuals was assessed by a Durbin-Watson statistic of [redacted] and finally normality was tested by a Q-Q plot. Absence of multicollinearity was assessed by using the Variance Inflation Factor (VIF). All independent variables had a VIF score below 5, except of the variables ‘industrial’ and ‘project manager B’ which correlated with their interaction term, which means that the variability in independent variables is not explained by other independent variables (Hair et al., 2010). Hereafter, the multiple regression could be carried out.

First the model fit was examined with the help of table 6. The coefficient of determination (R^2), in this case [redacted]%, tells how much of the variance in cost growth can be explained by the model. This value applies only for the sample. To know what the model fit would be in the population, the adjusted R^2 is used. Table 6 shows that in the population [redacted]% of the variance in cost growth can be explained by the model. This means that also other circumstances or characteristics which were not taken along in the regression model influence cost growth.

Table 6 – Model summary of the multiple regression model

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	[redacted]	[redacted]	[redacted]	[redacted]

a. Dependent Variable: Cost growth
b. Including interaction effects: [redacted]

With an ANOVA test, the statistical significance of the model was examined (table 7). In other words, the ANOVA test compares of the model with independent variables (model 1) is better in predicting cost growth compared to a model without independent variables (intercept model). The result of this ANOVA test is expressed in the F-score of [redacted], which is obtained by dividing the mean score of the regression model by the mean score of the residual. (The mean scores are in their turn the result of dividing the sum of squares by the degrees of freedoms). The p-value for the F-score is less than the significance level of 5% ($p < 0.05$), so it can be stated that there is statistical evidence (with $\alpha = 5\%$) to conclude that model 1 is significant better in predicting cost growth compared to the intercept model.

Table 7 – ANOVA table of the multiple regression model.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Residual	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]			

a. Dependent Variable: Cost growth
b. Including interaction effects: [redacted]

The significance of the model (see table 7) implies two denotations. Besides it is better in predicting cost growth it also means that the model 1 significantly better fits to the data than the baseline model. This does however not mean, that all the independent variables add significantly to the model. To find this out, a t-test is applied. The scores of the t-test can be translated to a p-value. When the p-value is lower than the significance level of 5% or 10%, it can be stated that the concerning variable significantly predicts cost growth. In this case, table 8 shows that there is statistical evidence (with α = 5% or 10%) that the [redacted] have a significant influence on cost growth. Besides these main effects, there is also statistical evidence (with α = 5% or 10%) that four interaction effects have a significant influence on project performance. With the help of the unstandardized B-coefficients of the significant variables it is possible to predict the cost growth as shown in equation 4. The constant of [redacted] is based on the reference categories and implies that when the reference categories are applied, this will lead to a cost growth of [redacted]. The cost growth will change when one of the significant independent variables is present in a tender or project. For example, when the same project will be carried out in the industrial market while all other variables will remain exactly the same, the project performance will changes from a cost growth of [redacted] to a cost growth of [redacted] (= [redacted]). So instead of a cost underrun, the project will result in a cost overrun. It must be kept in mind that this equation only explains [redacted]% of the variance in cost growth, so also other conditions will have an influence on project performance.

Cost growth = [redacted] (4)

Besides the unstandardized B-coefficients, also the standardised Beta-coefficient provides information. To assess the impact of each of the significant variables on the cost growth, the variables must be measured and compared on the same scale. By standardising the variables, all data is transformed to a mean of 0 and a standard deviation of 1 through which it becomes possible to compare the impact. The larger the standardised regression coefficient, the larger the impact it has on cost growth (Hair et al., 2010). Looking to table 8, it shows that the industrial market has the largest impact on cost growth, followed by project manager B and the interaction term of reimbursable contract and the industrial market.

In the remaining of this chapter, the results of all independent variables will be discussed by means of their hypotheses.

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[a] With a significance level of 5%, [b] With a significance level of 10%

Table 8 – Coefficients and significance of the independent variables (including interaction effects)

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t-value	Sig. (p-value)
1	(Constant)					
	Location – Netherlands (R)					
	Location – Other countries					
	Client main market – Oil & Gas (R)					
	Chemicals					
	Energy & Environment					
	Health & Nutrition					
	Infrastructure					
	Industrial					
	Property & Public sector					
	Type of contract – Fixed (R)					
	Type of contract - Reimbursable					
	Disciplines					
	Tender manager – Tender manager (R)					
	Project manager					
	Department manager					
	Engineer					
	Other					
	Discount ratio					
	Project manager – Zero experience (R)					
	Project manager C					
	Project manager B					
	Client attitude – Client attitude 1 (R)					
	Client attitude 2					
	Client attitude 3					
	Client attitude 4					
	DCN					

a. Dependent Variable: Cost growth
(R) = Reference category

* Significant at 5% significance level
** Significant at 10% significance level

5.4.1 Location of the project (X_1)

In the theoretical framework it was hypothesised that projects carried out in the Netherlands will have a better project performance compared to projects carried out in other countries. Knowledge about the local conditions, facilities and law and regulations were underlying this hypothesis (Dissanayaka & Kumaraswamy, 1999; Kim, et al., 2008; Bosch-Rekveldt et al., 2011; Chanmeka et al., 2012). The model showed however that there is no statistical evidence (with $\alpha = 5\%$) to conclude that Tebodin projects carried out in the Netherlands perform on average better compared to Tebodin projects carried out in other countries. Therefore, hypothesis one is rejected. Although this result is in contrast with the literature, there may be some explanations for this result. The literature examines mainly the influence of project location in the construction industry, whereby weather, basic infrastructure and accessibility of the site were found as variables influencing project performance. These are variables that are particularly important in executory operations at the site, while Tebodin is an engineering company. The engineering variables with respect to project location as underground utilities, geographical locations and host country conditions possibly have less influence on the project performance. Furthermore, it became clear during univariate analysis of the variable that the sample contained only [redacted] projects carried out abroad. This proportion is possibly too small to find a significant difference between projects carried out in the Netherlands and carried out in other countries.

5.4.2 Industry (X_2)

For the second independent variable, the market of the client, it was hypothesised that the more mature the industry is with respect to project management, the better the project performance will be. This hypothesis was based on previous studies indicating that more mature project management markets do better acknowledge the importance of a clear project scope and the provision of information. The engineering, construction and petrochemical industry were identified as most mature project industries, while the manufacturing industry appears to be the least mature project industry (Ibbs & Kwak, 2000; Cooke-Davies & Arzymanow, 2003; Grant & Pennypacker, 2006; Project Management Solutions, 2014). Table 8 shows there is statistical evidence (with $\alpha = 5\%$) that Tebodin projects carried out in the industrial market perform on average worse compared to projects carried out in the oil and gas market. Within Tebodin, the industrial market ranges from factories in the automotive industry to consumer products and electronics and pulp and paper (Tebodin, 2018). Products which can also be attributed to the manufacturing industry, which supports the hypothesis. However, also other markets within Tebodin contain clients in the manufacturing industry but did not turn out to be significant. Because no hard evidence is present, hypothesis 2 is rejected.

Examining the data on variable level, it is difficult to compare the characteristics of the oil and gas market (n = [redacted]) and the industrial market (n = [redacted]) because of their difference in proportions. The most conspicuous difference, is the difference in [redacted] as shown in figure 25. Around [redacted]% of the contracts in the industrial market are reimbursable contracts, while this proportion is [redacted]% in the oil and gas market. Table 8 showed that reimbursable contracts have a [redacted] project performance compared to fixed price contracts. This could partly explain the significant difference in project performance between the industrial and oil and gas market. Possibly, most of the difference can be explained by causes which are not included in the model.

Because the cause why projects carried out for clients in industrial markets perform on average worse compared to projects carried out for clients in the oil and gas market could not be found, it could only be stated that there is an association between the industrial market and project performance. Causality is out of question, because condition 3 (a plausible explanation for the effect) cannot be given.

Figure 25 – Dispersion in type of contract in the oil and gas market (left) and the industrial market (right)

5.4.3 Type of contract (X_3)

Regarding the type of contract, table 8 shows that there is statistical evidence (with α = 5%) that Tebodin projects with a fixed contract perform on average [redacted] compared to Tebodin projects with a reimbursable contract. So the hypothesis that the type of contract will not influence project performance, is rejected. This is remarkable, because studies by Ling et al (2004) and Suprapto et al. (2016) did not find any statistical relationship between type of contract and the project performance. However, the finding of Meng and Gallagher (2012) that fixed contracts lead to an increased project performance in construction industry shows resemblance with this study. In figure 26 [redacted] This could suggest that [redacted] contracts better motivates Tebodin's employees to stay within budget by increasing efficiency and using cost effective approaches. When the better project performance is not achieved by more efficiency, it could be at the expense of the quality (Ward & Chapman, 1994). Before such a statement can be made the data will be examined on variable level first.

Figure 26 – Dispersion of cost growth between fixed price contracts (left) and reimbursable contracts (right).

Looking to the data and mutual associations between contract type and the other variables, some results could explain the significant difference between fixed contracts and reimbursable contracts. [redacted]

[redacted]

Figure 27 – Dispersion of budget actual by fixed price contracts (left) and reimbursable contracts (right)

So, it seems that larger projects in terms of hours are more often offered with a [redacted] contracts. This analysis is supported by Figure 28. This finding is in line with Ward and Chapman (1994) in terms of motivation and increased efficiency. It seems logical that the less time an engineer has to fulfil his task (to a certain degree), the more efficient he will deal with his available time.

Figure 28 – Comparison of the estimated hours within fixed contracts (let) and reimbursable contracts (right)

Next to it, it is found that approximately [redacted]% of the fixed price contracts are offered for the oil and gas market relative to [redacted]% of the reimbursable contracts. The oil and gas market is traditionally the most important market of Tebodin. Consequently, it is more experienced with the type of projects within the market by which it is easier to assess the scope of a project. The determination of project scope is an important requirement for a positive project performance in fixed contracts (Meng & Gallagher, 2012; Suprapto, Bakker, Mooi, & Hertogh, 2016). Moreover, according to Cooke-Davies and Arzymanow (2003) the petrochemical industry is one of the most mature project management industries, by which the data flow from clients will be better which in turn will result in a clear project scope. [redacted]

Combining the cost growth of type of contract and the producer of the tender, it is visible in figure 29 that [redacted]

So it seems that not fixed price contracts perform better, but the type of projects it represents. Although an association between type of contract and project performance is proven by the regression model, it is not possible to state that there is a causal relationship between type of contract and project performance because alternative explanations can be given for the effect.

Figure 29 – Dispersion of the producer of the tender by fixed price contracts (left) and reimbursable contracts (right)

5.4.4 Disciplines (X_4)

The number of disciplines within a project represents the project complexity. Therefore, it was hypothesised that the more disciplines involved in a project, the less the project performance will be. The literature supports the results in this research with that. The regression model shows that there is statistical evidence (with $\alpha = 5\%$) to conclude that at Tebodin an increase of a single discipline in a project results on average in a decreased project performance. So, hypothesis 4 is accepted. Figure 30 visualises the decrease in project performance if the amount of disciplines in a project increases. It can be observed that more and relative larger cost overruns happen when the project [redacted] That seems to be straight, because both the structural and technical complexity increases (Baccarini, 1996; Williams T. M., 1999). The more disciplines involved, the larger the chances that one discipline influences another discipline or that one discipline is dependent on another discipline (structural complexity). Besides, the more disciplines involved the more tasks and technologies there are involved by which the complexity of a projects increases (technological complexity).

Regarding this variable, a causal relationship can be identified. The three conditions for causality are fulfilled: (1) the regression proved that there is an association between the number of disciplines and the performance, (2) first the number of disciplines is determined and afterwards the performance is assessed, so the effect is measured and (3) there is a plausible explanation for the decrease in project performance due to an increase in technological and structural complexity.

Figure 30 – Dispersion of cost growth categorised by number of disciplines

5.4.5 Tender manager (X_5)

In the theoretical framework it was hypothesised that the different producers of a tender will have no influence on project performance because it was expected that the complexity of the projects tendered by tender managers is compensated with their expertise and experience. On the other hand, it was expected that the lack of experience of other employees in making tenders is compensated for smaller projects at which it should be easier to estimate the costs. Table 8 shows that there is statistical evidence (with α = 5%) that at Tebodin, projects tendered by engineers [redacted] compared to projects tendered by tender managers. Because Fong and Chu (2006) and Laryea (2012) found that the expertise of and knowledge sharing between tender managers leads to a better cost estimation, it seems that indeed the project magnitude influences the results. If this is the case and taking the result of Fong and Chu (2006) and Laryea (2012) into consideration, it possibly indicates that the expertise of the tender manager is insufficient to tender large projects.

Figure 31 shows the difference in project complexity of the projects tendered by tender managers and the projects tendered by engineers. Comparing the number of disciplines in projects tendered by tender managers and engineers, it becomes clear that the project complexity differs. Engineers offers approximately [redacted] % of the time a project ranging from [redacted] disciplines, while the number of disciplines for the tender manager ranges from [redacted] disciplines. So it seems that the project complexity is an explanation of the significant difference between projects tendered by tender manager and engineers within Tebodin. This shows resemblance with studies of Baccarini (1999) and Williams (1999) which already proved that increased project complexity results in a decrease in project performance.

Figure 31 – Dispersion of number of disciplines within projects tendered by tender managers (left) or engineers (right).

Another interesting observation, is that the engineers make in [redacted] % of the times tenders for themselves while the tender managers make all their tenders for other persons. [redacted] As discussed earlier in paragraph 5.4.3. experience and project management maturity of the market makes it easier to manage to a positive project performance.

Another variable that could partly declare the significant difference between tender managers and engineers, is the type of contract. Although the difference is not much, the tender managers offer in [redacted] % of the times a fixed contract, compared to the engineers who offer [redacted] % of the times a fixed contract. In paragraph 5.4.3. it was already found that projects with a fixed contracts [redacted] than projects with a reimbursable contract. [redacted].

The difference in performance between projects tendered by tender managers and engineers, seems to have several explanations. The cause seems not to be the producer of the tender itself, but the type of project the tender manager represents. Therefore, because it cannot be excluded that other project characteristics are the cause of the difference in performance, a causal relationship is impossible. It can only be stated with confidence that there is an association between the tender manager and the project performance. Finally, because it was impracticable to test the representativeness of the sample towards the population, no statements can be made about the generalisability of these results to the population.

5.4.6 Discount ratio (X_6)

The multiple regression model demonstrated that there is no statistical evidence (with $\alpha = 5\%$) to conclude that at Tebodin the discount ratio has a significant influence on project performance. Therefore, the hypothesis that the smaller the discount ratio the better the performance will be is rejected. This contradicts with studies of Fugar and Agyakwah-Baah (2010) and Rosenfeld (2013) who found that a too low tender price, which could be a result of a too large discount ratio, is one of the most important causes of a decrease in project performance in the construction industry. Possibly, these results cannot be generalised to the engineering industry. However, another explanation why the result of this research deviates from other studies, is that too few projects with a discount ratio were present in the sample to have a significant influence. [redacted]. Because of that reason, a simple linear regression with these [redacted] projects was carried out. The reason to choose for a simple linear regression instead of multiple regression, is that at least five observations per independent variable are needed (Hair et al., 2010). A sample of [redacted] projects is too small to carry this out for model 1. So, discount ratio was the only independent variable in the regression while cost growth remained the dependent variable. With regard to the generalizability, at least five observation are necessary for each independent variable although the advisable level of observations is 15 to 20 for each independent variable (Hair et al., 2010).

The aim of the linear regression was to find out of if discount ratio is a good predictor for cost growth (see appendix 13 for the detailed analysis). To check if the assumptions were met, linearity was assessed with scatterplot, independence of residuals was tested by the Durbin-Watson statistic (2.013), homoscedasticity was determined by visual inspection of a plot of standardised residuals versus predicted values and normality of residuals was established by a histogram of standardised residuals. Statistical evidence (with $\alpha = 10\%$) was found to conclude that discount ratio significantly predicts cost growth and accounts for 5% of the variance in cost growth (adjusted R^2). [redacted]

$$Cost\ growth = \text{[redacted]} \times\ discount\ ratio \qquad (5)$$

Table 9 – Coefficients table of the simple linear regression

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	[redacted]	[redacted]		[redacted]	[redacted]
	Discount ratio	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

a. Dependent variable: Cost growth
b. [redacted], $p < 0.1$
c. Adjusted R^2 [redacted]
*. Significant at 10% significance level

The result of the linear regression shows resemblance with the studies of Frimpong et al. (2003) and Larsen et al. (2015), who also found that, performance although this is not the most important cause, a too low tender price has an influence on project. However, this result of the simple linear regression cannot be used in combination with the results of the multiple linear regression because the presence of the other independent variables is not taken into consideration. The result only indicates that, [redacted]

5.4.7 Project manager (X_7)

In the theoretical framework it was hypothesised that the more experienced a project manager is, the better the project performance will be. The regression model in table 8 showed that there is statistical evidence (α = 10%) that Tebodin projects managed by a project manager [redacted] performs on average better compared to projects managed by employee who do no hold a project manager position. Through this result, hypothesis seven is accepted. To find out if the conditions for causality are met and experience indeed causes a better performance as demonstrated by Schmidt et al. (1986), the association between project managers and the other variables is checked.

[redacted] These projects seem to be at least larger and maybe more complex compared to the project managers without experience. This corresponds with the finding that project managers [redacted] also more often manage projects with a reimbursable contract ([redacted]%) compared to the project managers without experience ([redacted]%). It was already found in paragraph 5.4.3. that it is more difficult to manage reimbursable contracts to a positive result. To find out more about the complexity of the projects, a look was taken into the number of the disciplines within the projects. It turns out that [redacted]% of the project managers [redacted]'s projects contain six or more disciplines towards [redacted]% of the project managers without experience. Thus, even with larger and more complex projects, the projects managers are able to manage their projects to a better project performance.

This result corresponds with the studies of Schmidt et al. (1986), Iyer and Jha (2005) and Enhassi et al. (2009). They found that through experience the project management skills will increase which consequently leads to better project performance.

Figure 32 – Dispersion of budget actual managed by project managers without experience (left) and project managers [redacted] (right)

So it seems that all three conditions for causality are met: (1) the regression showed there is an association between project manager and project performance, (2) first the project manager is allocated to the project and afterwards the project performance is assessed, so the effect is measured and (3) the results corresponds with previous studies that more experience and better skills positively influence project performance and therefore the cause seems to be plausible. Because all three conditions are met, it can be stated that there is a causal relationship between the experience of a project manager and the project performance. However, [redacted]

Due to a deficiency of projects managed by a project manager [redacted], their project performance could not be assessed. It can be assumed that they have even more expertise and more experience compared to project managers [redacted], so they possible perform even better. With regard to project managers [redacted], their project complexity equalled the project complexity of project managers [redacted]. [redacted]

5.4.8 Client attitude (X_8)

Although it was hypothesised that more cooperative clients (regarding DCNs) would lead to a better project performance, this hypothesis must be rejected. [redacted] This result corresponds with the studies of Enhassi et al. (2009) and Cho et al. (2009) who also could not find any statistical relationship between attitude of the client and project performance. Only Doloi (2012) discovered that conflicts and disagreements between two parties significantly influenced cost overrun.

There are however several comments on this the concept of client attitude. During the study, it appeared that client attitude was more difficult to measure than initially thought. During conversations with involved project members, it became clear that the attitude of the client depends on several factors. For example, in general when some part of the work was not mentioned in the project scope, the client more easily agrees with additional work. As a result, the client attitude will receive a lower score. Nevertheless, sometimes some part of the work is assessed by the client as division of the scope, while Tebodin evaluates this part as additional work. In this case, the client attitude will be judged with a high score. In addition, also the attitude of Tebodin's project manager as the client's project manager play role. The one time the client's project manager wants to obtain a good result and is focused to stay within the budget at any cost, while the other time the client's project manager is more flexible. Also Tebodin's project manager influences the client attitude. If the client is kept informed about the project progress it is more easily to get reimbursed the additional work than when the client is told in the end that additional work is carried out and has to be paid.

[redacted]

5.4.9 DCN ratio (X_9)

Finally, for the last variable it was hypothesised that the less scope changes within a project, the better the project performance will be. The degree of changes was measured by means of the DCN ratio, at which the total cost of scope changes was divided by the actual budget. The regression model did not find enough statistical evidence (with $\alpha = 5\%$) to conclude that within Tebodin the DCN ratio has a significant influence on project performance. Therefore, the hypothesis must be rejected. Because several scholars did find a statistical relationship between additional work and cost overruns, although most of them are based on the construction industry, this result is remarkable (Kaming, et al., 1997; Sambasivan & Soon, 2007; Aziz, 2013). Because of that reason the data was examined on variable level, starting with cost growth in figure 33.

Figure 33 – Dispersion of cost growth of projects without DCNs (left) and projects with DCNs (right)

What catches the eye, is that approximately [redacted]

[redacted]

Figure 34 – Dispersion of cost underruns and cost overruns based on DCN ratio. Projects with a DCN ratio of 0% are left out of this figure

5.4.10 Interaction effects

Besides the main effects that appear in the regression model, also four interaction effects are observable in table 8. An interaction effect is the effect of a combination of two or more variables on the dependent variable (Field, 2009). It is interesting to look for interaction effects, because it improves the model fit of the regression model (De Veaux, Velleman, & Bock, 2016). So with the interaction terms, the model is better able to predict cost growth. The model fit increased by adding the interaction terms from [redacted].

Although [redacted], it is the combination of the variables which makes them a good predictor for cost growth. The combination of a [redacted] as can be seen in table 10. The project with this specific combination was identified as a dangerous leverage point and therefore effects the regression result. This case was however retained in the dataset because it is an ordinary observation it its individual characteristics but exceptional in its combination of characteristics (Hair et al., 2010).

Looking to the other interaction effects, it is observable that the combination [redacted]

Table 10 – Overview of the interaction effects in the regression model

Interaction effects	B	Sig.	Count of combination is sample
[redacted]	[redacted]		1
[redacted]			6
[redacted]			12
[redacted]			36

a. Dependent Variable: Cost growth
* Significant at 5% significance level
** Significant at 10% significance level

To find a cause of these interaction effects, the combinations of these variables were visually examined (and represented in appendix 14). It was [redacted]

[redacted] This relative high could be a reasonable explanation of the statistical significance of this interaction effect. For the other interaction effects, it is more difficult to point out a cause. Possibly, these result cannot be explained by the regression model.

6. Call to action

This chapter translates the results from the study to several recommendations. Various topics will be discussed: continuously learning, project ownership, project managers, discount ratio and DCNs.

The analysis in the previous chapter demonstrated that the current project approach led to an overall negative financial result. To make sure that overall project performance will improve, several recommendations are formulated. These actions are summarised table 11 and will be expounded afterwards.

Table 11 – Concrete actions (based on two topics) that improves overall project performance

[redacted]
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]

6.1 [redacted]

[redacted]

[redacted]

6.2 [redacted]

[redacted]

6.2.1 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

6.2.2 [redacted]

[redacted]

[redacted]

Figure 35 – Overview of the project performance of [redacted]

6.2.3 [redacted]

[redacted]

7. Conclusion

This chapter answers the research question. Next, the implications of the results will be expounded. Finally, the limitations of this study and recommendations for future research will be discussed.

The aim of this research was assessing the influence of tender and project characteristics on project performance. By finding out which tender and project characteristics influence project performance, it should be easier to make a better cost estimation and, on the other side, it gives the management handles to manage a project more easily within budget.

During the research, more than [redacted] tenders and projects were examined. This amount was the result of a linking process, at which [redacted]% of the projects could be linked to their original tender. A multiple regression analysis demonstrated that there was evidence to conclude that client main market[a], type of contract[a], and tender manager correlate with project performance and the number of disciplines[a] and project manager[b] have a significant influence on project performance. In table 12, the results are summarised:

Table 12 – Overview of the significant results following from the multiple regression.

Variable	Result of multiple regression	Underlying cause	Recommendation
[redacted]			

[redacted]

[a] With a significance level of 5%, [b] With a significance level of 10%

7.1. Limitations

This is one of the first studies with regard to project performance which is focused on academic problem solving as a result of taking a business problem as point of departure. Consequently the results of this research will be less generalizable to other companies or sectors, but therefore it is more useful for the client Tebodin. The strength of the study lies in the linking process of the tenders and projects. The links where checked in triplicate, to be sure that the tender variables were matched with the right cost growth. Due to this basis, it was possible to give Tebodin insight in their own project performance.

[redacted]

[redacted]

[redacted]

[redacted]

7.2. Future research

This study provides a foundation for future research. First of all, an additional study could be carried out to the design of a data feedback loop. This feedback loop would make active monitoring of project performance possible, which provides direct feedback. Due to this, trends will be more rapid identified allowing immediate intervention when necessary. Due to time constraints, it was not possible to examine the feedback possibilities in this research. Second, [redacted] Third, because the regression model only explained [redacted]% of the variance in cost growth, it would be interesting to find out which other factors also have an influence on cost growth. Other studies have already shown that qualitative project variables as for example leadership style, partners transparency and empathy and the knowledge of project members have an influence on project complexity and therefore project performance (Bosch-Rekveldt et al., Verbraeck, 2011).

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Appendices

Appendix 1 - Project execution

Appendix 2 – The results of the kick-off meeting and project approach

The study was started with a kick-off meeting at Tebodin. During this meeting, the project approach was determined according to the Project Management Body of Knowledge (PMBoK) method. The results of this kick-off meeting are shown in table 13.

Table 13 – The results of the kick-off meeting

No.	Topic	Applicable in this study
1	Safety and compliance	• Compliance training • Traffic safety
2	Objective	Two questions must be answered during the research: 1. How has Tebodin Netherlands or Tebodin North East quantitatively performed in the past X years on her projects which comply with…? 2. How can Tebodin Netherlands or Tebodin North East appraise their projects in the future based on results of the past?
3	Scope	Final product: Master Thesis, which goes with: • Introduction into Tebodin • Information about the tender process • Stakeholder analysis and conversations with stakeholders • Literature review • Master thesis part I • Weekly progress • Implementation plan / building a tool
4	Effort, cost, duration	Weeks: 1 – 6: Master thesis part I 7 – 19: Courses on university 20 – 30: Master thesis part II Besides, also +/- 2000 km travel distance to other offices of Tebodin.
5	Assumptions	• Required data will be delivered by Tebodin • Required availability of employees of Tebodin • Software to analyse data will be delivered by the University of Twente • Confidentiality shall not constitute a restriction
6	Constraints	• [redacted] • [redacted] • [redacted]
7	Risks	• The delineation of the research • Deviation towards assumptions
8	Dependencies	Master thesis part I must be approved before a start can be made with master thesis part II.
9	Resources	Organisational structure of the project.

Both master thesis part I and II were carried out with the assistance of a "kata project board", which assisted to make the project planning clear. By making the goals visible per week, an overview of the project was created which helped to achieve to deliver the project on time. The intermediate goals are shown in table 14 and table 15

Table 14 – Overview of the project approach in master thesis part I

Week	Intermediate goals	Actions
1	A general view of Tebodin	Conversations with different people within the organisation
	Get to know the tender process	Conversation with tender manager
		Reading tender documents
		Analyse the tender management database (week 3)
2	Focused research question	Frame the research question
	Stakeholder analysis	Making a list of stakeholders that are interesting for the topic
		Preparation of conversations with stakeholders
3	Stakeholder analysis	Conversations with stakeholders: Business Developer (1x), Tender Manager (2x), Project Control engineer (3x), Project Manager (4x), Management (3x) and Coordinator QOHSE (1x)
	Get to know the project process	Conversations with project control
		Conversations with project management
4	Methodology section finished	Reading literature
	Gathering data	Gathering project data
5	Theoretical framework finished	Reading literature
	Analysing usefulness of data	Linking project data with tender data
6	Finalise Master Thesis part 1	Fine-tuning Master Thesis part 1
		Preparation of Master Thesis part 2

Table 15 – Overview of project approach in master thesis part II

Week	Intermediate goals	Actions
1	Data linking	New check master thesis part I
		Linking data
		Have the links checked
2	Data analysis	Preparing data for analysis
		Descriptive statistics
3	Data analysis	Performing logistic regression
4	Data analysis	Performing multiple regression
5	Data analysis	A week extension
6	Interpreting results	Translating results to call to action
		Implementation plan
Christmas holidays		
Christmas holidays		
7	Writing report	Thesis for drat
8	Writing report	Review thesis
		Spelling check
9	Writing report	Final thesis
10	Presentation	Preparing presentation
		Trial presentation colloquium

Although the researcher was the project manager of this study, the project approach was defined in cooperation with the clients. During the weekly meeting, the progress of the research was discussed. The organisation structure of this study is shown in figure 36.

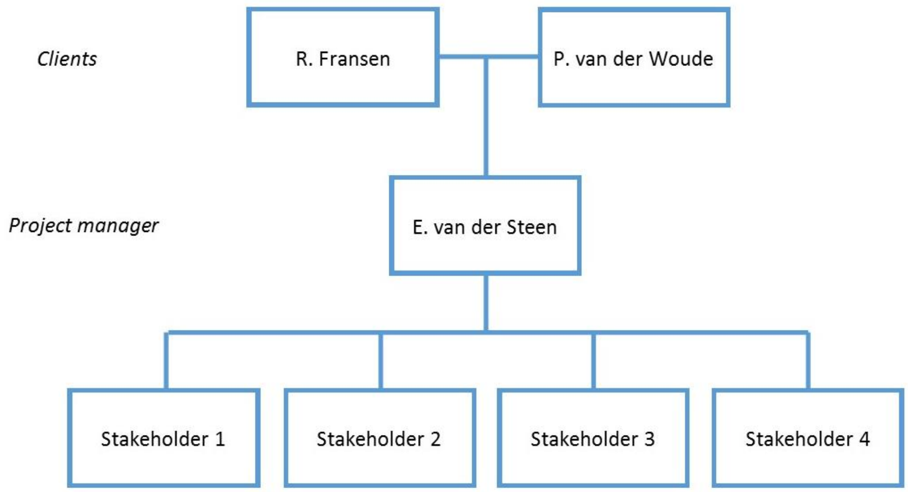

Figure 36 - The organisational structure of this study.

Through the conversations with different employees, the main stakeholders of this study were identified. These are: tender management, project control and project management. With the aid of the insights resulting from this research, tender management should be able to improve the cost estimation in their tenders. Both project control and project management could use the results to give attention to possible weaknesses, but also to optimise the strengths.

Appendix 3 – Various disciplines within Tebodin

The various disciplines that could be involved in a project are shown in table 16.

Table 16 – Overview of the disciplines according to the internal Tebodin coding.

Appendix 4 – Research design

Table 17 – Overview of the research design of this study.

Scope	Sample	Variables	Procedure	Research methodology
All projects (except of seconded projects) started from 01-01-2012 and finalised before 01-06-2017 within Tebodin North East	308 projects	One dependent variable: • Cost growth Six tender (independent) variables: • Location • Type of contract • Client's market • Tender manager • Disciplines • Discount given Three project (independent) variables • Project manager • Client's attitude • DCNs	1) Inventory of the tender process 2) Inventory of project management and control 3) Inventory of the available proposal and project data within Tebodin North East 4) Literature study based on the available data (variables) and their influence on project performance 5) Literature study on appropriate research methodology 6) Data preparation	1) Examination of the data 2) Descriptive statistics 3) Correlation analysis 4) Logistic regression 5) Multiple regression analysis

Research steps

To answer the sub questions, the research steps below have to be fulfilled:

1) Getting familiar with the tender process by reading tender documents, conversations with tender manager and take part of a proposal kick-off meeting. Simultaneously identifying variables of the tender process that are used to make a proposal and are saved in the [redacted] database.
2) Getting familiar with the project management and project control process by conversations with project managers and project controllers and looking at the project progress in [redacted] Simultaneously identifying variables of the project management and control process that are saved in the [redacted] database.
3) Identify which proposal and project data can be extracted from the [redacted] and thereafter identify how these data can be combined at project level.

4) Based on the available data, a literature study will be executed to discover how the variables affect the project performance. Given these information, hypotheses will be formulated.
5) The next step is to examine, based on the available data, which research methodology is most appropriate to examine the relationship between the dependent and independent variables.
6) When the method is determined, the data will be prepared for analysis. When strange values or differences are visible in the data than the project manager will be contacted to discuss the case. If needed the project will be deleted from the database, [redacted] Thereafter the data will be examined if it can be used on the following points: examination of missing data, examination of outliers, distribution of the data, relationship between variables, if the assumptions for multivariate analyses are met and incorporation of nonmetric data with dummy variable.
7) Execution of data analysis and translation of the results into management information.
8) When time permits, designing or advising how to make a system where future proposal and project data is updated and from which management information can be extracted.

Examination of the data:

1) Examination of missing data
    - Type of missing data
    - Extent of missing data
    - Randomness of missing data
    - Imputation method
2) Examination of outliers
    - Univariate detection
    - Bivariate detection
    - Multivariate detection
3) Univariate analysis
4) Bivariate analysis
5) Testing the assumptions of multivariate analysis and if needed transformation of the data
    - Normality
    - Homoscedasticity
    - Linearity
    - Absence of correlated errors

Appendix 5 – Overview of the requested data

[redacted]

Table 18 – Overview of the requested data.

Appendix 6 – Univariate analysis, bivariate analysis and multiple regression technique

Univariate analysis

As mentioned before, univariate analyses is used to discover abnormalities in the distribution of the value and in the dispersion of the variables. For categorical values, the univariate analyses will mostly consist of a frequency table or a bar chart to look at the distribution of the values. The metric variables are more interesting. To examine the distribution of the metric variables, the mean, median and mode must be analysed (see figure 37) (Bryman & Bell, 2015).

- Mean: This is the average score of the metric variable.
- Median: This is the mid-point in a distribution of values. It is, in contrast to the mean, not affected by outliers. The median can also be identified for ordinal values.
- Mode: This is the most common value in a distribution. Also the mode can be identified for nominal and ordinal values.

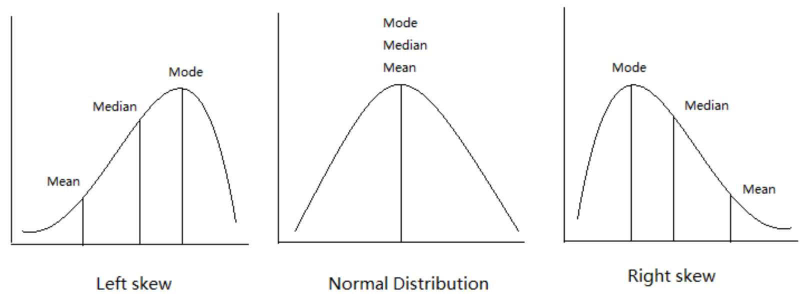

Figure 37 – The mean, median and mode indicating the distribution of a variable (Wyman, 2015).

Two other measures to identify the shape of the distribution are Kurtosis and skewness. The skewness of a distribution is shown in figure 37, where the left and the right distribution are skewed. A skewed distribution is an unbalanced and shifted distribution. A positive value for skewness implies that the distribution is moved to the left and a negative value implies a distribution to the right. The other measure for the shape of a distribution is Kurtosis. Kurtosis tells something about the steepness of flatness of the distribution in comparison with a normal distribution. An example of Kurtosis is shown in figure 38. Positive kurtosis indicates that the values cluster more about the mean relative to a normal distribution and are therefore called leptokurtic. Negative values on the other hand group less around the mean relative to a normal distribution and are therefore called platykutic (Hair et al., 2010).

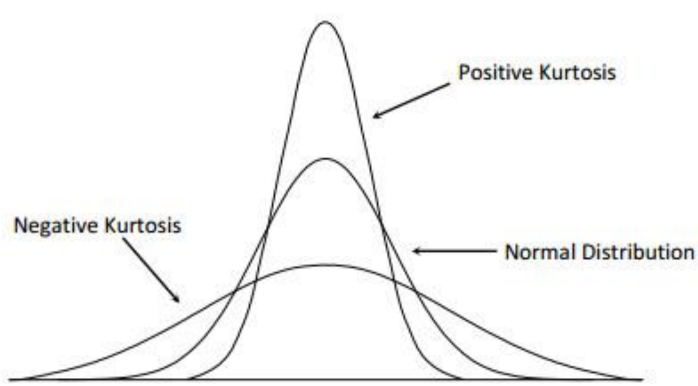

Figure 38 – A negative, normal and positive Kurtosis (StackExchange, 2015)

The dispersion of a distribution tells something about the variation in the sample (see figure 39). Common methods to measure the dispersion are the range and the standard deviation (Bryman & Bell, 2015).

- Range: This is the range between the minimum and the maximum value in a distribution.
- Standard deviation: This is the average amount of variation around the mean.

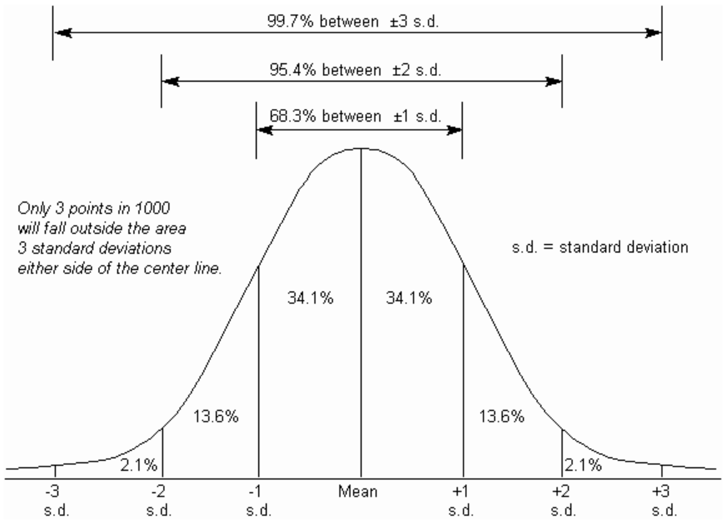

Figure 39 – Example of the standard deviations in a normal distribution (Syque, sd)

Bivariate analysis

Bivariate analysis is applied to explore the relationship between two variables. More precisely, it is examined if the variation of one variable concurs with the variation in another variable. This is shown in figure 40. Because the variance is shared, it is difficult to tell if the variance in the dependent variable Y, is explained by X_1 or X_2.

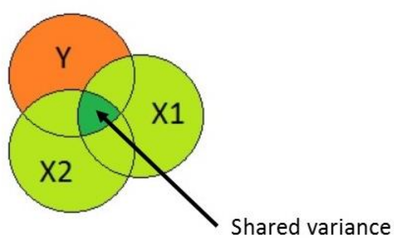

Figure 40 – Example of shared variance of two independent variables (X_1 and X_2) on the dependent variable (Y).

To examine the correlation between the variables, different methods should be used. They are all shortly explained below (Bryman & Bell, 2015):

- Contingency table: determines the relationship between nominal/nominal variables, nominal/ordinal variables and nominal/ratio variables. The contingency tables is an expansion on the frequency table, with two variables simultaneously analysed.
- Spearman's rho: determines the correlation between ordinal/ordinal variables and ordinal/ratio variables. The strength of the correlation is always indicated by the coefficient, which lies between 0 and 1. The stronger the relationship, the higher the score will be. The relationship can be both positive (+) and negative (-).
- Pearson's r: determines the correlation between two ratio variables. The strength and direction of the correlation are represented in the same manner as Spearmans's rho.

Because more independent variables are used, it is important to make a correlation matrix. With the aid of a correlation matrix, the correlation between the dependent and independent variables and the correlation between the independent variables can be identified. The correlation between the dependent and independent variables dissolves which independent variables the greatest predictive power. The correlation between the independent variables identifies possible collinearity (Hair et al., 2010). Table 19 is an example of a correlation matrix. It shows that variable 1 is the best predictor for the dependent variable, because it has the highest value corresponding with the Y value. It also indicates that variable 1 and variable 2 are correlated.

Table 19 – Example of a correlation matrix (Hair et al., 2010)

Variable	Y	Variable 1	Variable 2	Variable 3
Y	1.000			
Variable 1	.866	1.000		
Variable 2	.829	.673	1.000	
Variable 3	.342	.192	.301	1.000

Multiple regression

The technique behind a simple regression, is to predict a linear model where the independent variable predicts the dependent variable as well as possible. The difference between the estimate resulting from the model (ŷ) and the real value (y) is called the residual (ε), as shown in equation 1. The smaller the error, the better the model predicts 'the real world'.

$$\varepsilon = y - \hat{y} \tag{1}$$

The line that fits the best between the estimated values and all real values is the line where the sum of the squared residuals is the smallest. This line is called the least squares line or regression line and is shown in figure 41.

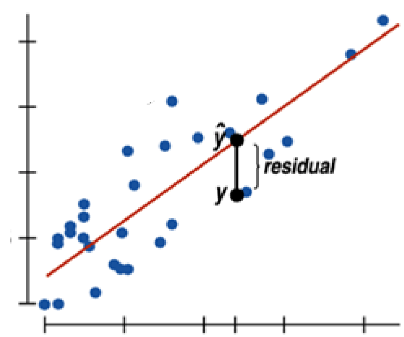

Figure 41 – Regression line (de Veaux, Velleman, & Bock, 2016)

The formula for the regression equation is as follows:

$$\hat{y} = b_0 + b_1 x \tag{2}$$

where b_0 is the intercept (the value that predicts $\hat{y}$ when x is zero) and b_1 is the slope (the change in the dependent variable due to the independent variable) of the regression line. The slope indicates the magnitude and the direction of the independent variable. The real values can be calculated by means of equation 3:

$$y = b_0 + b_1 x + \varepsilon \tag{3}$$

With multiple regression, the technique is the same as the simple regression, it is only carried out with more coefficients (de Veaux, Velleman, & Bock, 2016).

Before the regression can be started, the categorical variables have to be converted into dummies before they can be used for the regression analysis. A dummy variable is a metric variable used to represent a single category of categorical variable. Therefore, indicator coding is used (Hair et al., 2010). Table 20 shows how this process works:

Table 20 – Converting the independent variable X_7 (Experience of the project manager) in dummy variables.

Categorical value (X_7) – Experience project manager	New D_1	New D_2	New D_3
1 =	1	0	0
2 =	0	1	0
3 =	0	0	1
4 =	0	0	0

Category 4 (more than 10 years), is the reference category. The reference category is represented in the constant term of the regression model, and the group differences will be measured towards this reference category (Hair et al., 2010). An example of the formula with dummy variables:

$$y = b_0 + b_1 x + b_2 D_1 + b_3 D_2 + b_4 D_3 + \varepsilon \tag{4}$$

These dummies will be applied in the regression model formulae. The standard formula in multiple regression to describe the 'real world' is shown in equation 6:

$$Y_i = \propto + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \cdots + \beta_K x_{Ki} + \varepsilon_i \tag{5}$$

where Y is the value of the dependent variable, α is a constant, β is the estimated regression coefficient, X is the value of the independent variables, ε_i is the error term which is a random variable with mean 0, i is index of the performance metric being predicted and K is the number of independent variables or parameters (Ling et al., 2004).

How well the model fits the reality, is expressed with the squared correlation (R^2). It indicates how well the independent variables explain the amount of variance in the dependent variable. The score of the squared correlation is always between 0 and 1. The higher the score of the squared correlation, the better the model comes close to the reality (de Veaux et al., 2016).

Logistic regression

With logistic regression, the probability that an event will occur is predicted. This probability is expressed as "*the expected value of Y, given the value of X*" (Hosmer & Lemeshow, 2000). The probability can be calculated with equation 6:

$$E(Y|x) = \beta_0 + \beta_1 x \tag{6}$$

The value of this probability ranges between and one (Hosmer & Lemeshow, 2000; et al., 2010). This is also shown in figure 42, where the relationship between the dependent variable and the independent variables is stated.

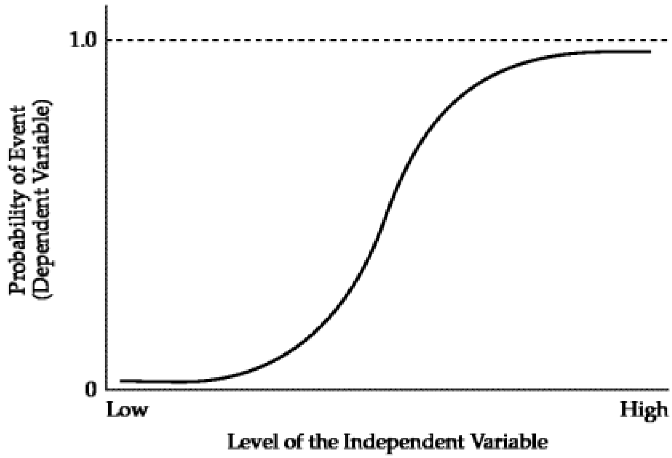

Figure 42 – The relationship between the dependent and independent variables is expressed by a logistic curve (Hair et al., 2010)

Another way to assess the chances to win a tender is by using odds. An odd of 1.5 indicates that the chances to win a tender are 1.5 times more likely to than losing a tender. It is however not possible for odds exceed the lower limit of zero, therefore logit value are be used. The logit value can be computed by taking the logarithm of the odds. Figure 43 shows that probabilities smaller than 0.5 will result in odds smaller than 1 and negative logit values. The other way around applies for probabilities greater than 0.5 which results in odds greater than 1 and positive logit values.

Probability	Odds	Log Odds (Logit)
.00	.00	NC
.10	.111	−2.197
.30	.428	−.847
.50	1.000	.000
.70	2.333	.847
.90	9.000	2.197
1.00	NC	NC

NC = Cannot be calculated.

Figure 43 – Values of probability, odds and logit values (Hair et al., 2010)

To estimate the model fit, the maximum likelihood method is used which is comparable with the least squares method for multiple regression. Both the odds as the logit value can be used as measurement of the dependent variable. The values of both can be calculated with the formulas below:

$$Odds = \left(\frac{probability_{event}}{1-probability_{event}}\right) = e^{b_0+b_1X_1+\cdots+\,b_nX_n} \tag{7}$$

$$Logit\ value = \ln\left(\frac{probability_{event}}{1-\ probability\ _{event}}\right) = b_0 +\ b_1X_1 + \cdots +\ b_nX_n \tag{8}$$

As shown in both formulas, more than one independent variable can be used to predict the logit value or odds for a dependent variable. The better the estimated logit values or odds predict the actual values, the better the model fit. The model estimation is conveyed with -2LL which is -2 times the log of the likelihood value. A perfect fit matches with a -2LL score of zero (then the likelihood is one), so the lower the score of -2LL the better the model predicts the reality.

Assessing if the independent variables improve the model fits, consists of three steps. First, the model fit of the null model (excluding independent variables) has to be determined, thereafter the model fit of the proposed model (including independent variables) has to be ascertained and thereafter the difference between the null model and the proposed model has to be assessed. If the model fit of the proposed model has improved significantly, than it can be stated that the independent variables do improve the model estimation fit.

Appendix 7 – Detailed description of the linking process of the proposals and projects

Appendix 8 – Encoding of the data

After linking the projects with their corresponding tender, the data had to be encoded. In the following part, the encoding process of the variables will be described shortly.

Appendix 9 – Representativeness of the sample

Appendix 10 – Logistic regression

In this appendix, the logistic regression will be discussed step by step. It starts with data-examination (univariate and bivariate analysis, missing values, outlier) followed by testing the assumptions and finally the regression model will be shown.

Appendix 11 – Cost growth versus budget actual

In this appendix, the cost growth based on budget actual are stated.

Figure 44 – Overview of the cost growth per categorisation of actual budget

In the figure below, the Δactual costs – budget actual based on budget actual are stated:

Figure 45 – Overview of Δ actual costs – budget actual categorised by actual budget.

Appendix 12 – Multiple regression

The same approach will be used here to execute the multiple regression.

Appendix 13 – Simple linear regression discount ratio

Appendix 14 – Visualisation of the interaction effects