PRE-ASSESSMENT OF PROJECT PERFORMANCE: A DUTCH CONSTRUCTION CASE

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Abstract

Knowing in advance if a project becomes a success, requires well-thought pre-assessments. Project-oriented organizations are struggling with these, which is in this research studied from the perspective of a Dutch contractor. Applying an explanatory research approach, historical projects' performance and characteristics are analyzed to learn lessons for future projects. Literature on project performance and risk management are therefore elaborated, the former as represented by Transaction Cost Economics, the latter as represented by Early Warning Signs and Critical Success Factors. A dataset of 45 projects is created, including financial data, contractual agreements, and project team experience. Variables for stepwise regression are derived from the dataset, with financial coverage as dependent variable. A positive correlation is revealed between initial coverage and actual coverage. Seven other variables turned out to be insignificant. Because of their justified importance, these are discussed in an expert panel, indicating four additional factors affecting pre-assessments: complexity, early client collaboration, project team selection, and scheduling. Leading to the conclusion that accuracy and effort in pre-assessments can result in alignment between estimated and actual (financial) performance. However, strong interdependencies between factors should be accounted for. It is suggested to adopt accepted risk management techniques to obtain accurate pre-assessments of projects.

Keywords: *Project performance, project characteristics, Critical Success Factors, Early Warning Signs, Transaction Cost Economics, construction industry*

1. Introduction[1]

If project success could be perfectly assessed on forehand, the world of project-oriented organizations would always be bright. In practice, it turns out that such assessments are not that simple. In this paper a study on project performance and (pre-)assessment is presented to contribute to this ideology. Throughout the introduction, the research is further sketched by defining the problem, research question, and its relevance. Lastly, further outline of the paper is provided.

1.1. Problem statement

"Construction projects are executed in a dynamic environment characterized by uncertainties in budgets, technology and project delivery system" [1]. Besides, the construction industry is known for its inefficiency in operations and processes for quite some time [2]. Because of the high uncertainty, inefficiency, and risks, contractors face difficulties in successful project delivery and making profit. The holy grail to overcome these problems: perfect pre-assessments of projects, upon which participation in a tender and the tender sum can be determined.

Hegeman faces similar problems as described above. Not surprisingly, they also strive for completer and correct pre-assessments of projects. This implies that the phase before submitting the tender, i.e., the acquisition phase, is key.

To understand the importance of the acquisition process, and its implications for project succession, the dynamics of the construction industry and construction management are sketched. Traditionally, "various functions of the process (of a single project) are organized into economically distinct firms which relate to each other through transactions governed by contractual relations" [3]. A contractor and client sign a contract, in which is described that the contractor should build a specified asset for a specified price,

[1] This paper presents the thesis for graduation of MSc Business Administration at University of Twente. Since the master is the second, after MSc Construction Management & Engineering, this thesis is executed at a Dutch construction contractor; Hegeman Bouw & Infra (in short: Hegeman). See also: https://hegeman.com/.

after which the client puts the asset into use. Fortunately, given the complexity of construction projects, collaboration between client, contractor and third parties started to develop towards integrated forms of collaboration, rather than classical, adverse client-contractor relationships [4-6].

Given (increasing) complexity of construction projects [2], involved parties want to identify and act upon risks and possibilities as soon as possible. The sooner these can be detected, the better. The studies of Williams, Klakegg, Walker, Andersen, and Magnussen [7] and Haji-Kazemi, Andersen, and Krane [8] emphasize the importance of early warning signs (EWS) in projects, though they are not easy to detect nor act upon. Performance and EWS identification are depending on the type of project, organizational culture, and the project environment [8]. As a contractor, Hegeman is active in a broad range of project types; from infrastructure to utility construction, to transformations of existing buildings. Besides, organizational culture of clients differs, such as the project environment.

1.2. Research question

To improve pre-assessments of future projects, it is of importance to have knowledge about past projects' successes and failures. Therefore, the **main question** (MQ.) of the study is formulated as follows:

MQ. What lessons can be learned from historical projects, in pre-assessment of future projects' performance?

To obtain a manageable process towards answering this question, **three sub-questions** (SQ.) are defined:

SQ1. How can construction project performance be defined?

SQ2. What correlations can be found between historical projects' performance and project characteristics?

SQ3. Which implications can be derived from historical projects analysis for future projects?

1.3. Research approach

The research follows a mixed-method, explanatory design [9] (see Chapter 3 for further elaboration). Initially, a literature review is conducted to provide insight towards performance and risk in construction projects. In combination with project data of the facilitating organization, this answers to SQ1. By means of stepwise regression, followed by an expert panel, correlations between performance and project characteristics are made insightful (SQ2.). Implications of these two (SQ3.), answer to MQ. The research as described, is presented in Figure 1.

1.4. Relevance of the study

The study's relevance is split in two parts, respectively practical and theoretical. The former provides expectations regarding implications for the facilitating organization, Hegeman. The latter concerns the expected implications for the related study fields of performance and risk management of projects, and construction management.

Practical relevance

The facilitating organization, Hegeman, currently struggles with pre-assessment of project performance. By structuring information and data

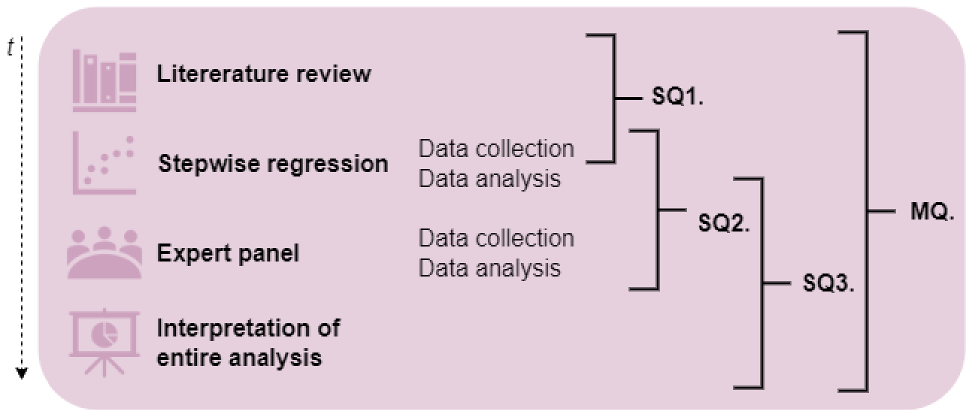

Figure 1: Simplified representation of the research design

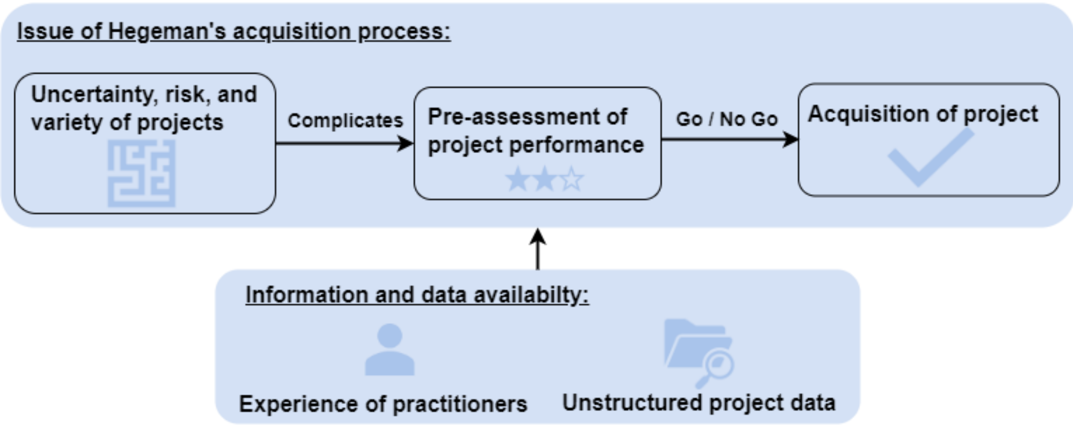

Figure 2: Schematization of Hegeman's issue

within the organization, the study helps Hegeman to structure data in such a way that pre-assessment of projects is made insightful and clear.

Also, the study attempts to classify potential project success, based upon project characteristics of historical projects. In this way, Hegeman could improve the acquisition process by selecting on projects with specific characteristics (or exclude projects with certain characteristics).

To limit failures, delays, and cost overruns, Hegeman desires an analysis of (historical) data, to identify project risks and opportunities in a premature phase. The managing board claims a broad set of information and data of projects, however, they do not know how to use the information and data sources for analysis. According to the managing board, there is a well-structured document management system, unstructured information regarding acquisitions and tenders, and knowledge and experience of employees. Figure 2 schematizes the issues as described above.

Eventually, factors which are specifically critical for the case of Hegeman are indicated. These factors contribute to qualification and suitability of existing Critical Success Factors (CSFs) in performance management literature on (construction) projects.

Theoretical relevance

In a broad sense, the proposed study falls within the fields of performance management and risk management of projects. From the perspective of a contractor, these are applied in the context of the construction industry. Based upon the problem context and theoretical background, the study contributes to qualification of information systems' improvements, and risk management in projects focusing on EWS.

There is reasoned towards performance management and risk management as pillars for construction project assessment, nurtured by information systems and CSFs.

Practical and theoretical relevance summarized in Figure 3.

1.5. Outline of the paper

The paper proceeds with elaborating on the theoretical background (Chapter 2), resulting in a theoretical framework for the study. The methodology of the mixed-method, explanatory research is specified by a quantitative (stepwise regression) and qualitative (expert panel) part (Chapter 3). Results of the two are presented in Chapter 4. Finally,

Figure 3: Schematization of thesis' practical and theoretical contribution

interpretation of the results, limitations, and implications are included in Chapter 5.

2. Theoretical background

Since the study is executed in the context of a project-oriented environment, first project performance and performance management are defined (Section 2.1). As a widely accepted approach, Transaction Cost Economics (TCE) is used to extend upon project performance (Section 2.2). Second, since the construction industry is known for its high risks and uncertainties, performance can't be seen apart from managing risk (Section 2.3). Risk management in then explained by means of Early Warning Signs (EWS) and Critical Success Factors (CSFs) in Section 2.4. Eventually, Section 2.5 presents the theoretical framework.

2.1. Project performance

Assessing project performance is crucial for an organization's continuity. However, "given the complexity and progress of construction projects, such predictions require critical project information used to evaluate project performance" [10]. The review study of Moradi et al. [10] revealed the balanced scorecard framework as most useful for project-oriented organizations over the past two decades. In addition, they prioritized project success factors, with *safety* as most important, followed by *cost, quality, scheduling, productivity, client satisfaction, profitability, team satisfaction, environment,* and *sustainability*.

Where Moradi et al. [10] reviewed the project as a whole, already in 1988, Pinto and Slevin [11] published a study identifying CSFs per project phase, respectively conceptual, planning, execution, and termination. Tough, the studies have overlapping factors and factors which relate to each other, overall, the sets of CSFs have quite big differences. One outstanding factor which occurs is the safety aspect. The study of Chan, Scott and Chan [12] revealed social and physical environment and 'implementing an effective safety program' as project success factors, which relate to safety. In 2010, Toor and Ogunlana studied performance indicators for megaprojects, where safety turned out to be most important together with efficiency and effectiveness.

Dainty, Cheng and Moore [13] found a lack of consensus in previous construction performance literature. As a result, they produced nine performance criteria. However, almost two decades later we can still conclude that there is no consensus on project performance criteria given the variety of CSFs published in later studies [10, 12, 14].

From a different perspective, project performance can also be assessed in terms of transaction costs, which should be minimized to achieve project success. Winch [3, 15] was the first one to apply TCE, as invented by Williamson [16], to assess project success in construction. Later, Li, Arditi and Wang [17] specified 26 determinants of transaction costs in construction projects (elaborated in Section 2.2)

Overall, literature on project performance in construction projects is inconclusive about the perfect way of assessment, i.e., by means of KPI's, CSF's or TCE. Where KPI's and CSFs are more or less the same, TCE is a completely different approach towards project success. Based upon the problem context of an issue and goal of the research a suitable framework should be chosen to deal with the matter.

Performance issues of projects are highly correlated to (unforeseen) project risks. Information and data are fundamental in learning and managing such risks. The recent literature review of Moradi et al. [10] revealed the balanced scorecard framework as quite efficient in evaluating project performance. The study of Martinsons, Davison and Tse [18] predicted promising implications of the balanced scorecard, and they turned out to be right. As presented by Martinsons et al. [18], in the context of improving information systems, innovation and learning lead to competence, which increases performance (see Figure 4).

Since TCE is an accepted way of measuring project performance, the next section elaborates further on this topic. Besides, performance can't be seen apart from (managing) risk; Sections 2.3 and 2.4 examine risk management of projects.

Figure 4: Simplification how innovation and learning lead to improved performance by applying and continuously improving Information Systems (derived from [18])

2.2. Transaction Cost Economics (TCE)

In 1989, Winch [3] was the first to apply a transaction cost approach to construction (project) management. Williamson [16] defines TCE as: "The transaction cost approach to the study of economic organization regards the transaction as the basic unit of analysis and holds that an understanding of transaction cost economizing is central to the study of organizations.". Since the research of Winch, TCE in construction management research is widely applied given multiple cited studies in the field [1, 15, 17, 19, 20]. The works of Li, Arditi, and Wang [1, 17] eventually resulted in 26 determinants of transaction costs, which form a base for coding and categorizing collected data.

The complete image of costs of a construction project goes beyond production cost only, and involve "preparing a bidding document, estimating, drawing up a contract, administering the contract, and dealing with any deviations from contract conditions" [17]. Therefore, they define four categories for determinants of transaction costs: (1) role of the owner, (2) role of the contractor, (3) transaction environment, and (4) project management efficiency.

In addition, Lu et al. [20] discovered hidden transaction costs in conflicts and disputes, which are often neglected but should be considered. Though, some of these hidden factors relate to one or more of the determinants of transaction costs of Li et al.[17], they are relevant to keep in mind. They divided hidden transaction costs into five factors, (1) reputation, (2) cooperation and trust, (3) emotion, (4) time and (5) execution of judgement. Consciously evaluating those factors contributes to minimization of transaction costs in case of conflicts. In general, an extensive evaluation of transaction costs results in negotiation rather than continue blaming as the preferred option for all parties involved.

In conclusion, it can be said that managing (increasing) transaction costs, goes hand in hand with mitigating and managing risk. Because of construction's nature, there are high uncertainties, and therefore high risks. More specific, a study of Cantarelli, Van Wee, Molin, and Flyvbjerg [21] in the Netherlands revealed important emphasis on the relation between pre-construction time and cost, and eventual project cost overruns.

2.3. Managing risk in projects

Risk can be defined as the "effect of uncertainty on objectives" [22]. Eliminating all risks in a construction project is an utopia. However, "prevention of financial risks is one of the major tasks that construction companies have to pay attention to" [23]. ISO 31000 [22] provides a cyclical structure for risk management, where risk assessment forms the center of the process (see Figure 5). IEC 31010 [24], from ISO 31000 [22] defines 31 risk assessment techniques for organizations, varying from subjective methods such as brainstorming towards more sophisticated techniques such as the Delphi method or Markov analysis.

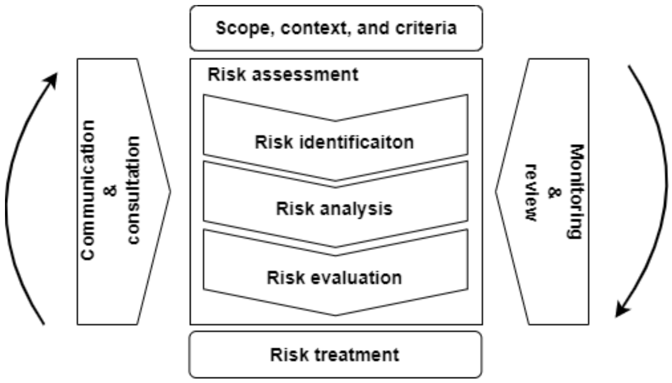

Figure 5: Risk management process (derived from [22])

From risk management theory, Chen et al. [23] examine the use of derivatives to hedge financial risk of construction companies. They present a model that can predict whether a construction company has reached the financial level where they are ready to safeguard against financial risks with derivative use. Though, the authors conclude that using derivatives as risk hedging tool is feasible, its effectiveness highly depends on experience and its process is complex.

The intangibility of risks results in different perceptions of managers over projects, since project risk characteristics, and the internal and external environment over projects are different [25]. Since risks in projects are not only intangible, but also inevitable, Kwak and LaPlace [25] state that risk (tolerance) management should be encountered by means of five steps: (1) A risk management plan should be drawn up which focuses on risk tolerance of the firm, but also with regard to participants and stakeholders of the project. (2) Review compensation policies for project managers and other employees. When salary is at risk based on performance this can increase or decrease decision-makers risk aversion. (3) Organizations need to possess a culture that supports proper risk-taking and innovation, i.e., risk-taking should be well-thought and measured. (4) Thorough review of project managers understanding and vision on risk tolerance. (5) Adopt an outside view in risk assessments [26].

As discussed in the previous section, Martinsons et al. [18] reasoned how improvement of information systems can contribute to improved performance because of innovation and learning. From Kwak and LaPlace [25], it can be implied that this goes hand in hand with a well-thought risk management procedure. We learned that innovation and learning [18] are at the base of good performance. Data from past practices is an essential input to achieve, or even start, with innovating and learning. So, business practices and project characteristics should be secured in a dataset, to form a basis for innovation and learning. From a contractor's perspective, Alzahrani and Emsley [27] revealed turnover history, quality policy, adequacy of labor and plant resources, waste disposal, size of past projects completed, and company image to be most significant CSFs. Together, these factors determine project success, cost overruns, and delays. In addition, the submitted tender sum plays a key role for the contractor's project success. Therefore, factors which influence the height of the tender sum, are critical. Which are respectively, market condition, project complexity, quality of information and flow requirements, availability of design information, client's changes in owner's requirements, project team's experience of the construction type, method of construction, inadequate tender documentation, expertise of consultants, and site investigation [28]. The accuracy of estimating such factors at the acquisition phase can significantly improve the tender sum's accuracy [29, 30].

2.4. Early Warning Signs (EWS) and Critical Success Factors (CSFs)

Both hedging by derivatives and a risk tolerance management process considers firm-broad matters. For projects, they are quite complex tools, highly depending on practitioners experience [23]. Projects come and go disregarded if the right firm structure exists to be exposed to such risks and performance issues. Therefore, prevention and detection of project risks is key. Risk prevention can be obtained by well-thought risk management processes, e.g., from Kwak and LaPlace [25].

Since risk is nurtured by uncertainty [22], complete prevention is an utopia. If risks are not prevented, they need to be detected, preferably as early as possible; i.e., EWS should be identified on time [7, 8]. It can save work-hours, and thus prevent or decrease budget overruns [31]. Several studies depicted lists of EWS in (construction) projects [7, 31-34]. Based upon an empirical study, Williams et al. [7] present a list of important EWS at project setup, in early stages, and during project execution. Given the problem context, the former is of importance, but its function will not be effective if data of past projects' early stages and execution characteristics are lacking. During the setup, there should be thought of why to undertake the project, project definition, business plan, definition of scale, resources, and assumptions. Haji-Kazemi, Andersen, and Krane [8] build further upon the work of Williams et al. [7], by presenting a framework for categorization of EWS according to various aspects. It is about detecting problems, measure their impact on performance, take appropriate actions, for which they categorize thirteen EWS sources.

Literature on risk management in project-oriented organizations can be done by prevention, detection (EWS), tolerance of risks, and evaluation by means of CSFs. These types of risk management largely match with the '4Ts of risk response' on risk management in general: tolerate, treat, transfer, and terminate [35]. Though, construction projects are unique, they have a repetitive pattern. Therefore, for this study the aspects of prevention and evaluation can't be neglected, by only focusing on risk respondence as described by Hopkin [35]. As mentioned in the previous section, IEC 31010 [24] depicts 31 risk assessment methods. The methods largely overlap with the thirteen EWS sources of Haji-Kazemi et al. [8], who examined the impact and predictive power of each source.

2.5. Theoretical framework

To (pre-)assess projects, a definition of project performance should be known. In conclusion, performance management is nurtured by information systems and CSFs [10-14], and has causality with

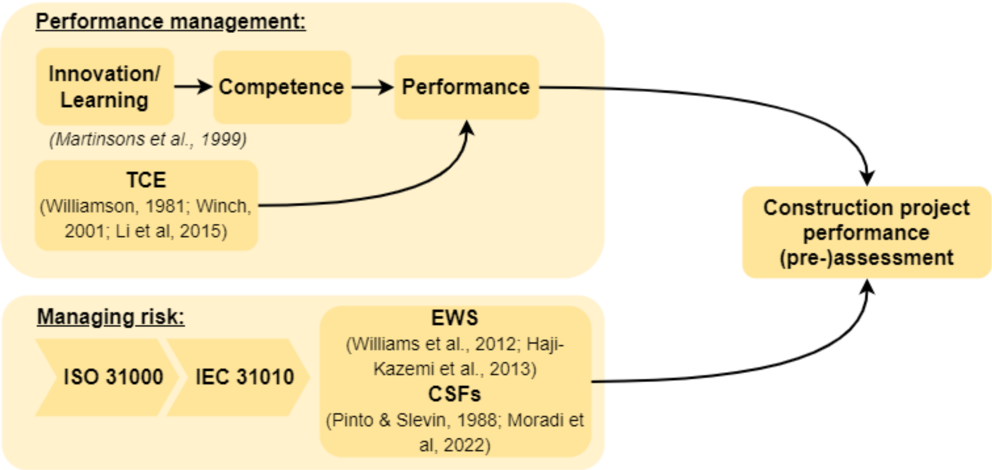

Figure 6: Schematization of theoretical framework

innovation and learning, and competence [18]. In addition, transaction costs are an important measure of performance [15-17]. Because of high complexity and uncertainty of construction projects [2], and given the definition of risk [22]; performance can't be seen apart from risk. Therefore, from the risk management standard of ISO [22], and proposed measurement techniques [24], reasoning towards EWS-sources [7, 8], which have similarities with CSFs [10, 11]. Figure 6 schematizes the theoretical framework of the thesis as elaborated in this section. TCE, EWS, and CSFs are mainly applied for justification purposes for variables selection and validation, as discussed in Chapter 3 Method.

3. Method

A mixed-method research approach with explanatory design is applied in the research (see Figure 7) [9]. Emphasis of the study is on the first, quantitative part, where stepwise regression analysis is applied (Section 3.1). Thereafter, propositions regarding project performance are presented and discussed in an expert panel (Section 3.2). Justification why this approach is applied, is elaborated in Section 3.3.

3.1. Part I – Stepwise regression[2]

The theoretical framework (see Section 2.5) and explorative interviews with acquisition managers and project managers (Appendix A) provide input for data collection and analysis of the quantitative part (see sub-sections 'Model specification' and 'Research design' below). Both are elaborated in this section, working towards a stepwise, linear regression model (see Equation 1).

Equation 1: Mathematical representation of traditional regression model

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i + u$$

y Dependent variable (DV)

x_i Independent variable i (IV)

β_0 Intercept (constant), β_i Slope coefficient of x_i

u Error term

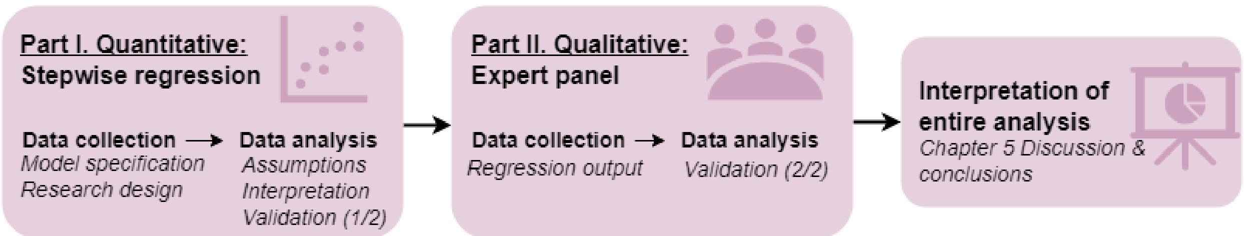

Figure 7: Explanatory, mixed-method research design (interpreted from Creswell and Plano Clark [9])

[2] Structure of the regression part is derived from the course 'Quantitative and Design Methods in Business Research' of MSc Business Administration at University of Twente.

Model specification
To proceed with the research as proposed, a dataset consisting of finalized projects is required. Within the facilitating organization, this led to 45 projects (see Appendix B for selection criteria and details about contents of the dataset). To gain insight into Hegeman's projects' prioritization, performance measures, and way of working, explorative interviews are taken with practitioners in acquisition and realization of projects (see Appendix A). In addition, the interviews provide practical input for variable selection.

Project performance is the main thread of the research. In this study, the *actual coverage of a project is taken as definition of performance* (see Equation 2). It is important to note that this is not same as profitability, for which overhead costs must be accounted.

By means of stepwise regression analysis, it is attempted to estimate a linear regression model for actual project coverage. Initially, eight independent variables (IVs) are derived from the project data (as in Appendix B). In an iterative way, the most suitable combination of IVs is estimated[3]. Table 3 provides specification of variables, and justification either by research related purposes or literature.

Equation 2: Definition of project performance for the research

$$Actual\ coverage = \frac{Actual\ revenues - Actual\ costs}{Actual\ costs}\ [\%]$$

Research design
45 projects are included (Appendix B), which is mediocre for regression analysis. Following Cohen [36] (see Table 1), with $N = 45$, only relative large correlating variables can be found ($d = 0{,}4$), at the 95%-level (assuming max. 6 IVs), and 99%-level (assuming max. 2 IVs). Though, statistic significant correlations might not be present for all IVs, implied coefficients ($\beta\ In$) of excluded variables of the stepwise regression can still be verified and validated by means of literature (Chapter 2) and experiences of practitioners (i.e., Part II – Expert panel). To check for influential observations, the DV is plotted against each potential IV (Appendix D, section D.11).

Table 1: Expected power based on number of data points and IVs (derived from Cohen [36])

No. of IVs	$\alpha = 1\%$			$\alpha = 5\%$		
	$d = 0.02$	$d = 0.2$	$d = 0.4$	$d = 0.02$	$d = 0.2$	$d = 0.4$
2	698	97	45	481	67	30
3	780	108	50	547	76	34
4	841	118	55	599	84	38
5	901	126	59	645	91	42
6	953	134	63	686	97	45
7	998	141	66	726	102	48
8	1039	147	69	757	108	50

Assumptions
General assumptions about regression analysis apply and are elaborated by the regression output (Appendix D), as referred to for each assumption (see Table 2).

Table 2: Assumptions of the regression analysis

Assumption	Appendix section
• Constant variance of the error term.	D.3. Method for variable entrance/removal
	D.4. Model summary
• Uncorrelated and independent error terms.	D.2. Correlations
	D.6. Coefficients
	D.7. Excluded variables
• No perfect multicollinearity.	D.8. Collinearity diagnostics
• Normality of the error term.	D.10. Standardized residual plots
• Linear relationship.	D.11. Partial regression plots

Interpretation and validation of the results
Results of the stepwise regression analysis are interpreted by considering (see also Sections D.1 up till D.7):

[3] See the article on 'Stepwise Regression' for a concise elaboration on this type of regression approach.

- (Adjusted) coefficient of determination ($\bar{R}^2$ and R^2).
- Regression coefficients and their significance.
- Standardized regression coefficients.
- Entrance/removal of IVs in stepwise procedure (see also Appendix D.3 and D.7):
  - Entrance: $Prob. of\ F\ to\ enter\ \leq 0{,}50$.
  - Removal: $Prob. of\ F\ to\ remove \geq 0{,}100$.
- Validation of the results is in two-fold:
  - Residuals statistics (Appendix D.9).
  - Excluded variables and the applied model are discussed in part II – Expert panel.

3.2. Part II – Expert panel[4]

Explanatory research designs lend themselves well to explain (in)significant correlations from the quantitative phase, by means of the qualitative part [37].The regression results and theoretical background (Chapter 2), are used as input for an expert panel. The combination of the two leads to propositions how Hegeman, and other practitioners in the industry can improve pre-assessments of projects.

Validation: Propositions based on regression output

Given low data availability (see Section 3.1), it can be expected that stepwise regression results removal of several IVs. The removed, and therefore insignificant, IVs can only be indicated with presumed coefficients, and IV 'Scheduling' was excluded on forehand, because of too few data points (see Table 3). Though, whether removed or not, the selection of these variables is on purpose, and justified on forehand by literature and/or relevance for the study.

Interaction effects

Considering justification of excluded and removed IVs, seven propositions are presented and discussed by the expert panel (see Section 4.2). In addition, the overall model with selected variables and their interactions are discussed. The presentation with propositions, used during the expert panel is included in Appendix E.

3.3. Justification of approach

Initially, 8 IVs are specified (see Table 3), based upon the literature review (Chapter 2) and explorative interviews (Appendix A). Considering the limited set of 45 projects, and the corresponding expectations from the power analysis (see Table 1), it can't be expected that a regression model with 7 or 8 IVs provides significant, reliable results. Therefore, a stepwise approach is chosen, to estimate the best fit given all variables.

Though, all variables specified, are considered relevant because of either relevance for the research or literature (see column 'Justification' in Table 3). Therefore, it is decided that variables removed during the stepwise regression procedure, should not be neglected. Since they can't be significantly quantified, a qualitative follow-up is chosen. Considering the interplay between time and result in the research, an expert panel is valued higher than conducting separate interviews.

4. Results

The results are presented in the same structure as presented in Chapter 3 Method. Part I – Stepwise regression is then split in two parts, respectively the structured set of project data, and regression output based on project data. Thereafter, the expert panel's propositions derived from the regression analysis, are presented and discussion of each proposition is reported. Overall, this chapter forms the basis for interpretation of the results (Chapter 5 Discussion & conclusions).

4.1. Part I – Stepwise regression

Since there was little structure in the dataset of Hegeman, the data collection part is a result in itself for the organization. Besides, the regression output is relevant to learn from past projects and apply acquired knowledge to future projects.

Structured set of project data

As stated in Section 1.4, information and data availability within Hegeman where restricted to experiences of practitioners, and unstructured project information. By explorative interviews with managers (Appendix A), and gathering several types of project information (Appendix B), a structured set of 45 finalized projects is created.

The structured dataset is for Hegeman a result in itself, since it provides a template which can be easily

[4] As defined by Hartmann (2017, p. 148), from the course bundle 'Research Methodology & Academic Skills' of MSc Construction Management & Engineering at University of Twente.

Table 3: Variables' specification

Variable[5]		Type	Unit / options	Justification	Obtained by	Data points	Measure for missing data completion
DV	Actual coverage	Metric	[% of 'Actual costs]	As provided as definition of project performance in this research.	Financial project data	45 of 45	N/A
IV1	Initial coverage	Metric	[% of 'Initial costs']	Provides insight towards the accuracy of pre-assessed performance.	Financial project data	40 of 45	[redacted]
IV2	Actual contract price	Metric	[€]	As measure of project size [21].	Financial project data	45 of 45	N/A
IV3	Additional work	Metric	[% of 'Actual contract price']	TCE: 'Change orders' [17].	Financial project data	45 of 45	N/A
IV4	Acquisition costs	Metric	[% of 'Actual costs']	Represents effort in pre-assessment, i.e., EWS 'project assessment' and 'performance measurement' [8].	Financial project data	36 of 45	[redacted]
IV5	'Bouwteam'	Nominal	Yes No	TCE: 'Early contractor involvement', 'Completeness of design', 'Integration of design and construction' [17].	Contract documents and realization managers	45 of 45	N/A
IV6	Experience of project team	Nominal	Unique project type Similar project experiences	EWS: 'Past project consultation' [8]; TCE: 'Experience in similar type project' [17].	Realization managers	45 of 45	N/A
IV7	Type of acquisition	Nominal	Tender (i.e., public) Non-public	Publicly available tenders have in potential more candidates that non-public procedures with pre-selection or one to one awarding.	Realization managers	45 of 45	N/A
~~IV8~~	~~Scheduling~~	Metric	[% delay of initial planning]	CSF: 'Scheduling' [11].		29 of 45	Too few data points, excluded from analysis.

[5] There is no hierarchy/difference in importance between IVs, IV numbering is only included for practical reasons.

complemented with future projects, and was non-existent before.

Regression output
From Appendix B can be derived how project data is used as input for defining regression variables. From these variables, a .csv-file is created for the regression input (Appendix C). The complete output of the stepwise regression run is included in Appendix D.

Considering a 95%-confidence interval, one IV remains ('Initial coverage'), resulting in a model with descriptive statistics as in Table 4 and model summary as in Table 5. Based on the F-criterion (see Appendix D.3), all other IVs are excluded. However, their estimated statistics (see Appendix D.7) indicating an alleged correlation are still relevant as input for the expert panel (see Section 4.2).

A wrap-up of the regression results is given in Figure 8.

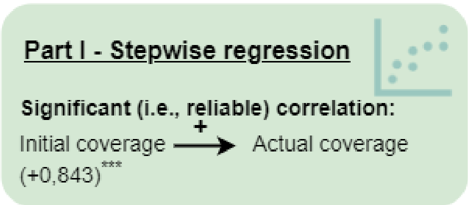

Figure 8: Wrap-up of results Part I - Stepwise regression

4.2. Part II – Expert panel

The expert panel is included for validation purposes. At first, for IVs which are not reliable enough, i.e., insignificant, to include in the regression model. Though, they are perceived as important, so propositions based on alleged correlations are drawn up and discussed. Besides, the expert panel's opinion is asked about the model suitability and completeness.

Panel discussion on propositions
All insignificant IVs and the deleted IV8 'Scheduling' are translated into a proposition and presented to the expert panel, resulting in seven propositions (see Table 6). As elaborated in Section 4.1, alleged correlations for insignificant IVs are derived from the regression output (see Appendix D.7). Time intervals (TI) refer to the transcript section in Appendix F, applicable to the respective proposition.

Model suitability
To check for model suitability, the expert panel concludes with two questions. Respectively, 'Provides this set a good overview of project performance?' and 'How to deal with interdependencies of IVs?' (see TI8 in Appendix F). The expert panel concludes with four factors, they believe are critical, in performance pre-assessments:

- Verification and validation accuracy.
- Correct usage of project governance tools and structure of project team.
- Project post-assessments.

See Figure 9 for a wrap-up of the expert panel results.

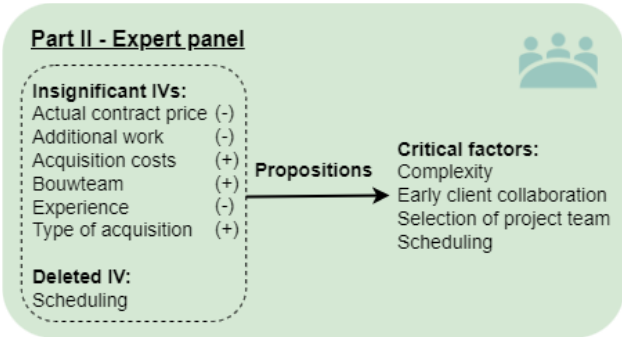

Figure 9: Wrap-up of results Part II - Expert panel

Table 4: Descriptive statistics

	Coefficient (β)	Mean	Std. Deviation	N
Constant (β_0)	6,776			
IV1 Initial coverage (β_1)	0,843	10,9009	5,77193	45
DV Actual coverage		15,9691	12,52152	45

Table 5: Model summary[b]; with *** implying significance at the α=1% level.

R	$\bar{R}^2$	SE of estimate	F	Sig.	Df	Durbin-Watson
,389[a]	,131	11,66996	7,656	0,008***	43	1,652

a. Predictors: (Constant), InitialCoverage; b. Dependent variable: ActualCoverage

Table 6: Expert panel proposition results

Expert panel proposition		Related IV	Alleged correlation from regression	Discussion result	Time interval (TI) (see Appendix F)
P1.	Project size is negatively correlated to project performance.	IV2 Actual contract price	−	Correct if the sum exceeds 'simple human imagination'; rather complexity than price only.	TI2
P2.	Additional works pressurize performance since overhead costs are relatively high.	IV3 Additional works	−	Inconclusive.	TI3
P3.	Contractors pay too few attention to the acquisition process.	IV4 Acquisition costs	+	Inconclusive.	TI4
P4.	Early collaboration with the client, eventually results in higher performance.	IV5 'Bouwteam'	+	Correct, also strong correlation with IV3.	TI3
P5.	Performance depends on project team experience.	IV6 Experience of project team	−	No. Selection of suitable project team, rather than experience.	TI5
P6.	(Medium)large contractors should stay away from public tenders.	IV7 Type of acquisition	+	Inconclusive.	TI6
P7.	Detailed scheduling is key for a good estimate of initial performance.	IV8 Scheduling	N/A	Correct, strong correlation with IV1.	TI7

5. Discussion & conclusions

Results of the stepwise regression and expert panel form the basis for conclusions of the study. Starting with interpretation of these results, and limitations, mainly due to limited data availability, are discussed. Considering these two, theoretical and practical implications are provided. Lastly, suggestions for future research are included.

5.1. Interpretation of results

The relation between project performance and project characteristics was studied, where project performance is defined by actual coverage. During the first part of the research, a stepwise regression is applied with DV 'Actual coverage' and 8 provisional IVs. One significant positive correlation between DV and one of the IVs could be found, respectively 'Initial coverage' (α=0,01).

This correlation implies that Hegeman is quite good in estimating actual project coverage in a pre-mature phase, given a coefficient near 1 (respectively +0,843). However, the adjusted R-squared of 0,131 reveals that this model with initial coverage only, declares a small part of project performance.

Other variables that could not be quantified, are validated in the qualitative part by means of an expert panel. Based on their expertise the following statements are made:

- If project complexity increases, (potential of) project performance decreases, because of higher uncertainty in risks.
- Early collaboration with the client initially seems a costly and disadvantageous investment, though eventually it is beneficial for performance.
- The right selection of project team members is key, rather than project team experience.

- ❖ Detailed scheduling strongly affects the quality of initial coverage estimates.

5.2. Limitations

Limitations of the study are largely related to limited availability of data. The dataset as applied for the regression analysis consisted of 45 projects. Also, the variable 'Scheduling' could not be included in the analysis, as a result of too few data points (29 out of 45), though it was emphasized as important factor [11], also during the variables selection period.

Since construction is a people's business [38], there will always be some subjectivity. Therefore, it is of importance that such an analysis, that could contribute to better pre-assessments remains objective. Though, it is tried to keep only objective data, prioritization for variable selection, and validation of the regression results is done by means of field practitioners, which always encounter some subjectivity.

Also, interaction effects among IVs are neglected. However, a relatively low adjusted R-squared, and emphasize of strong correlations between IVs by the expert panel presume that interaction effects play an important role. By applying a stepwise regression approach, the majority of initial variables is excluded. On the one hand this results in a good model-fit, on the other hand, this neglects interaction effects, which are emphasized by the expert panel.at

5.3. Theoretical implications

Considering interpretation of the results, and its limitations, the implications for the construction industry and follow-up studies, is threefold:

- ❖ Accuracy and effort in pre-assessment of construction project performance can result in reliable outcomes.
- ❖ Complexity, early client collaboration, project team selection, and scheduling are key factors in estimating reliable project coverage, i.e., performance.
- ❖ In practice, strong interdependencies exist in EWS and CSFs, which should be stricter encountered to improve alignment between theory and practice.

5.4. Practical implications

Practical implications of the study concern Hegeman and similar type organizations. Three implications/recommendations are provided:

- ❖ As part of the data collection for the regression analysis, a structured set of project data is delivered to Hegeman. Before, there was no structured set of project data, combining relevant characteristics. The dataset and regression tool can easily be extended with future projects.
- ❖ From the regression results, Hegeman can conclude that they are already quite good in pre-assessment, and that effort in these indeed pays off.
- ❖ Regarding risk management, Hegeman can learn from the framework of Kwak and LaPlace [25] by implementing "thorough review of project managers understanding and vision on risk tolerance", which is consistent with the conclusions from the expert panel to include project post-assessment. Therefore it is advised to "adopt an outside view in risk assessments" (e.g., [24]) within the organization [26].

5.5. Future research

Follow-up studies should strictly consider the limitations of this research. It is suggested to further investigate interaction effects between project characteristics, since these are neglected in the study as presented.

Only one organization is used in this thesis. Future research might combine several of these single case studies, working towards a review study, to built a robust pre-assessment performance model. Eventually, this contributes to already accepted works on CSFs [11] and EWS [7, 8]. Broad definitions of risk and performance are applied during the study, such that studies in other fields than construction can relate and compare to this research.

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Appendix A. Documentation of exploratory interviews

A.1. Structure of the interviews

One the first steps for data collection of the project set is taking interviews with managers of Hegeman. Within the organization, there are two acquisition managers and three realization mangers. Four interviews are conducted with the two acquisition managers and two out of three realization mangers.

The interviews followed a structured approach, with the following steps/questions:

1. Which factors are most important for project success in you opinion?
2. Discussion about factors provided by interviewee.
3. Discuss appropriateness, applicability, and definition of potential variables as formulated in the proposal report (see Table 7).

Table 7: Proposed variables

Variable	Unit
Profitability	[%]
Project size	[€-interval]
Investment in pre-assessment(s)	[% of total project costs]
Working experience o project manager/project team	[years]
Type of project	[-]
Type of contract	[-]
Type of client	[-]
Frequency of client consultations	[-]
Client satisfaction	[1 – 10]
Scheduling	[1 – 10]

4. Working towards finalizing question, the same question as the first one: Which factors are most important for project success in your opinion?

A.2. Interview results

The most important factors for project success according to the interviewees are reported in Table 8. In Table 9, remarks of all interviewees on the proposed variables and definition are reported.

Table 8: Most important factors for project success according to interviewees

Initial factors	Additions/changes at end of interview
Interviewee 1:	
• Purchasing advantage. • Failure costs during execution. • Process management.	• Additional factor: follow-up projects.
Interviewee 2:	
• Pleasant working ambiance and job satisfaction. • Challenge.	N/A
Interviewee 3:	
• Job satisfaction. • Deduct negative project information from employees.	• Additional factor: relation with the client. • Additional factor: (de-)escalation.

Interviewee 4:

- Correctness of contractual documents.
- Project supervision.
- Scheduling.
- Additional factor: experience of the client.
- Additional factor: costs of additional work.

Table 9: Interviewees remarks on proposes variables

Proposed variable	**Remark(s)**
Profitability	N/A
Project size	• Trade-off between contract price and cost price. • Impact is also important, but hard to include.
Investment in pre-assessment(s)	N/A
Working experience of project manager/project team	• Take project team as a whole.
Type of project	• As defined within Hegeman: transformations, utility, civil, and services.
Type of contract	• Distinguish UAC 2012 and UAC-IC 2005.
Type of client	• Categories.
Frequency of client consultations	• Not relevant.
Client satisfaction	• Important, but hard to include.
Scheduling	• Expected versus actual time schedule.

Appendix B. Project data

Included as separate file: Appendix_B_Project_data.xls[6]. Below, there is elaborated on the project information provided in the separate appendix.

The projects in the dataset of the analysis are restricted to some criteria to ensure completeness of project data. At first, projects need be finalized, otherwise results could still change over time. Also, the projects should be conducted in the period 2019 – 2021. Hegeman's current financial software package became operative during 2018, therefore, project data of earlier projects is not complete anymore. At last, in case of alliances with other contractors, the secretary part should be at Hegeman to ensure all financial results are available.

The set meeting the criteria above consists of 45 projects, of which information is gathered as in Table 10.

Table 10: Overview of project information and selection options

Information	**Unit / Options**	**Variable in regression (see also** Table 3**)**
Project number	######	N/A
Project name	…	N/A
Year finalized	2019 2020 2021	N/A
Initial revenues	[€]	N/A
Initial costs	[€]	N/A
Initial coverage	[% of 'Initial costs']	IV1
Actual contract price	[€]	IV2
Actual costs	[€]	N/A
Actual coverage	[% of 'Actual costs']	DV
Additional work	[% of 'Actual revenues']	IV3
Acquisition costs	[% of 'Actual costs']	IV4

[6] Can be provided upon request via: roy.brinkhof@live.nl.

Information	Unit / Options	Variable in regression (see also Table 3)
Type of project (according to Hegeman's structure)	Infrastructure Services Transformation Utility	N/A
Administrative conditions[7]	UAV 2012 UAV-GC 2005 Other	N/A
Type of contract[8]	Design & Construct (D&C) Engineering & Construct (E&C) 'Prestatiecontract' 'Raamovereenkomst ingenieursdiensten' 'Traditioneel (RAW of STABU)' Design, Build, Finance, Maintain (DBFM) Design, Build, Maintain (DBM) Hybrid ('RAW o.b.v. UAV-GC 2005') Other	N/A
Bouwteam[9]	Yes No	IV5
Client name	…	N/A

[7] Options remained in Dutch for practical reasons. In English: UAC 2012 and UAC-IC 2005.
[8] See: https://www.pianoo.nl/nl/sectoren/gww/gww-contractvormen, some types remained in Dutch for practical reasons and applicability, indicated with '…'.
[9] Literally 'Construction team': sometimes applied in pre-mature phase of a project, where client and contractor actively work together on finalizing and finetuning the project plan. See also: https://www.bouwendnederland.nl/actueel/onderwerpen-a-z/bouwteam (in Dutch).

Information	Unit / Options	Variable in regression (see also Table 3)
Scheduling	$\frac{Actual\ days}{Scheduled\ days}$ [%]	IV8 (removed, too few data points)
Working experience of project team	Unique type of project Similar project type experiences	IV6
Acquisition form	Tender (i.e., public) Not public	IV7

Appendix C. Regression input

Included as separate file: Appendix_C_Regression_input.csv[10].

[10] Can be provided upon request via: roy.brinkhof@live.nl.

Appendix D. Regression output

Regression output is presented in the sections below. The .sav-file is also included as separate file: Appendix_D_Regression_output.sav[11].

D.1. Descriptive statistics

	Mean	Std. Deviation	N
ActualCoverage [%]	15,97	12,52	45
InitialCoverage [%]	10,90	5,77	45
ActualContractPrice [€]	1837249	2953921	45
AdditionalWork [%]	8,76	8,25	45
AcquisitionCosts [%]	1,97	2,59	45
Bouwteam [-]	0,36	0,48	45
Experience [-]	0,64	0,48	45
TypeOfAcquisition [-]	0,20	0,40	45

D.2. Correlations

		ActualCoverage	InitialCoverage	ActualContractPrice	AdditionalWork	AcquisitionCosts	Bouwteam	Experience	TypeOfAcquisition
Pearson Correlation	**ActualCoverage**	1,00	0,39	-0,17	-0,10	0,22	0,17	-0,16	0,15
	InitialCoverage	0,39	1,00	-0,09	0,10	0,41	0,13	-0,18	0,06
	ActualContractPrice	-0,17	-0,09	1,00	0,38	-0,24	-0,12	-0,23	0,20

[11] Can be provided upon request via: roy.brinkhof@live.nl.

	AdditionalWork	-0,10	0,10	0,38	1,00	-0,12	-0,02	0,22	0,13
	AcquisitionCosts	0,22	0,41	-0,24	-0,12	1,00	0,28	-0,08	-0,14
	Bouwteam	0,17	0,13	-0,12	-0,02	0,28	1,00	0,07	0,09
	Experience	-0,16	-0,18	-0,23	0,22	-0,08	0,07	1,00	-0,09
	TypeOfAcquisition	0,15	0,06	0,20	0,13	-0,14	0,09	-0,09	1,00
Sig. (1-tailed)	**ActualCoverage**		0,00	0,14	0,26	0,08	0,13	0,14	0,16
	InitialCoverage	0,00		0,28	0,25	0,00	0,20	0,12	0,36
	ActualContractPrice	0,14	0,28		0,00	0,06	0,22	0,07	0,09
	AdditionalWork	0,26	0,25	0,00		0,22	0,45	0,07	0,20
	AcquisitionCosts	0,08	0,00	0,06	0,22		0,03	0,30	0,19
	Bouwteam	0,13	0,20	0,22	0,45	0,03		0,33	0,27
	Experience	0,14	0,12	0,07	0,07	0,30	0,33		0,27
	TypeOfAcquisition	0,16	0,36	0,09	0,20	0,19	0,27	0,27	

D.3 Method for variable entrance/removal[a]

Model	Variables Entered	Variables Removed	Method
1	InitialCoverage	ActualCoverage ActualContractPrice AdditoinalWork AcquisitionCosts Bouwteam Experience TypeOfAcquisition	Stepwise (Criteria: Probability-of-F-to-enter <= ,050, Probability-of-F-to-remove >= ,100).

a. Dependent Variable: ActualCoverage

D.4. Model summary[b]

					Change Statistics					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**R Square Change**	**F Change**	**df1**	**df2**	**Sig. F Change**	**Durbin-Watson**
1	,389[a]	0,151	0,131	11,670	0,151	7,656	1	43	0,008	1,652

a. Predictors: (Constant), InitialCoverage

b. Dependent Variable: ActualCoverage

D.5. ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1042,615	1	1042,615	7,656	,008[b]
	Residual	5856,080	43	136,188		
	Total	6898,695	44			

a. Dependent Variable: ActualCoverage

b. Predictors: (Constant), InitialCoverage

D.6. Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	6,776	3,751		1,807	0,078	-0,788	14,339		
	InitialCoverage	0,843	0,305	0,389	2,767	0,008	0,229	1,458	1,000	1,000

a. Dependent Variable: ActualCoverage

D.7. Excluded variables[a]

						Collinearity Statistics		
Model		Beta In	t	Sig.	Partial Correlation	Tolerance	VIF	Minimum Tolerance
1	ActualContractPrice	-,132[b]	-0,93	0,36	-0,14	0,99	1,01	0,99
	AdditionalWork	-,139[b]	-0,99	0,33	-0,15	0,99	1,01	0,99
	AcquisitionCosts	,068[b]	0,44	0,66	0,07	0,83	1,20	0,83
	Bouwteam	,122[b]	0,86	0,40	0,13	0,98	1,02	0,98
	Experience	-,096[b]	-0,67	0,51	-0,10	0,97	1,03	0,97
	TypeOfAcquisition	,131[b]	0,93	0,36	0,14	1,00	1,00	1,00

a. Dependent Variable: ActualCoverage

b. Predictors in the Model: (Constant), InitialCoverage

D.8. Collinearity diagnostics[a]

Model		Eigenvalue	Condition Index	Variance Proportions (Constant)	InitialCoverage
1	1	1,886	1,000	0,06	0,06
	2	0,114	4,066	0,94	0,94

a. Dependent Variable: ActualCoverage

D.9. Residuals statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7,27	43,61	15,97	4,87	45
Std. Predicted Value	-1,79	5,68	0,00	1,00	45
Standard Error of Predicted Value	1,74	10,14	2,10	1,29	45
Adjusted Predicted Value	6,40	62,45	16,38	7,43	45
Residual	-23,70	25,69	0,00	11,54	45
Std. Residual	-2,03	2,20	0,00	0,99	45
Stud. Residual	-2,05	2,23	-0,01	1,01	45
Deleted Residual	-24,94	26,40	-0,41	12,38	45
Stud. Deleted Residual	-2,14	2,35	-0,01	1,03	45
Mahal. Distance	0,00	32,25	0,98	4,82	45
Cook's Distance	0,00	1,72	0,05	0,26	45

Centered Leverage Value	0,00	0,73	0,02	0,11	45

a. Dependent Variable: ActualCoverage

D.10. Standardized residual plots

Histogram

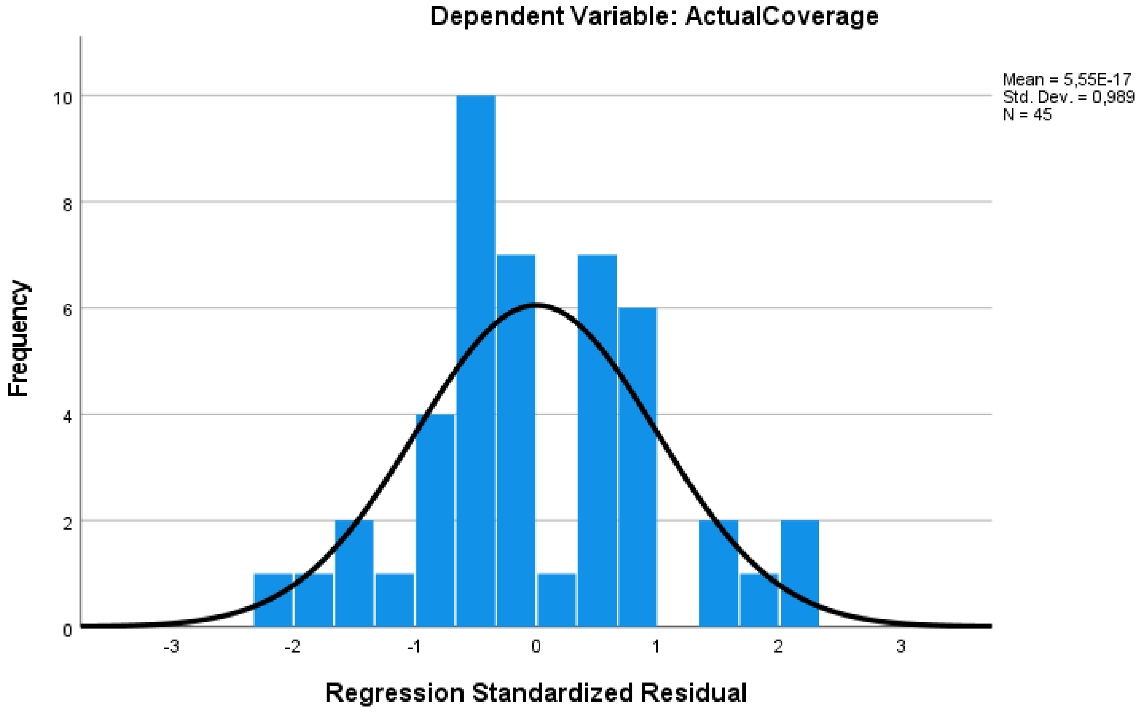

Figure 10: Histogram; normality of the DV 'Actual coverage'

Normal P-P Plot

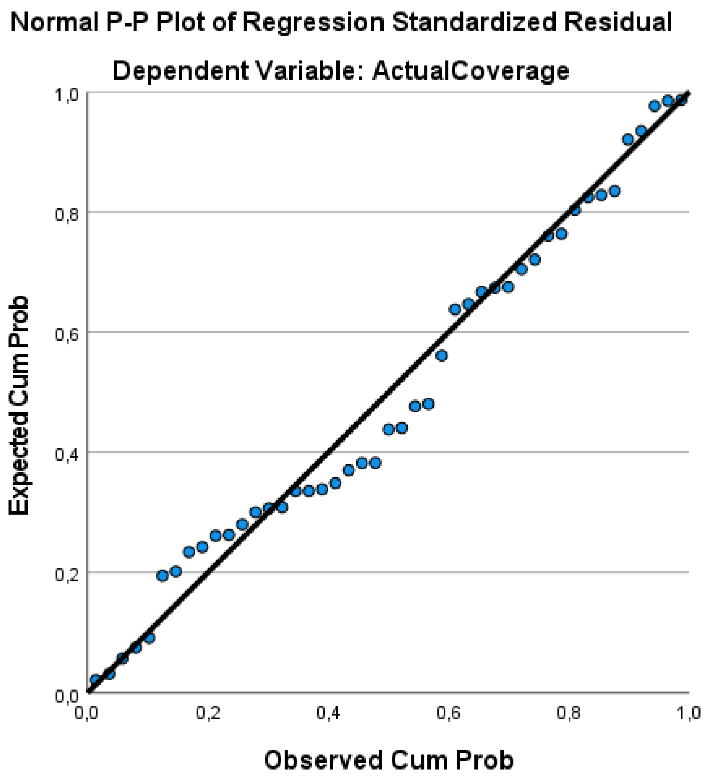

Figure 11: P-P plot; normality of the DV 'Actual coverage'

D.11. Partial regression plots

Partial regression plots of all seven IVs considered in the stepwise regression analysis are provided in Figure 12 up till Figure 18.

IV1 Initial coverage

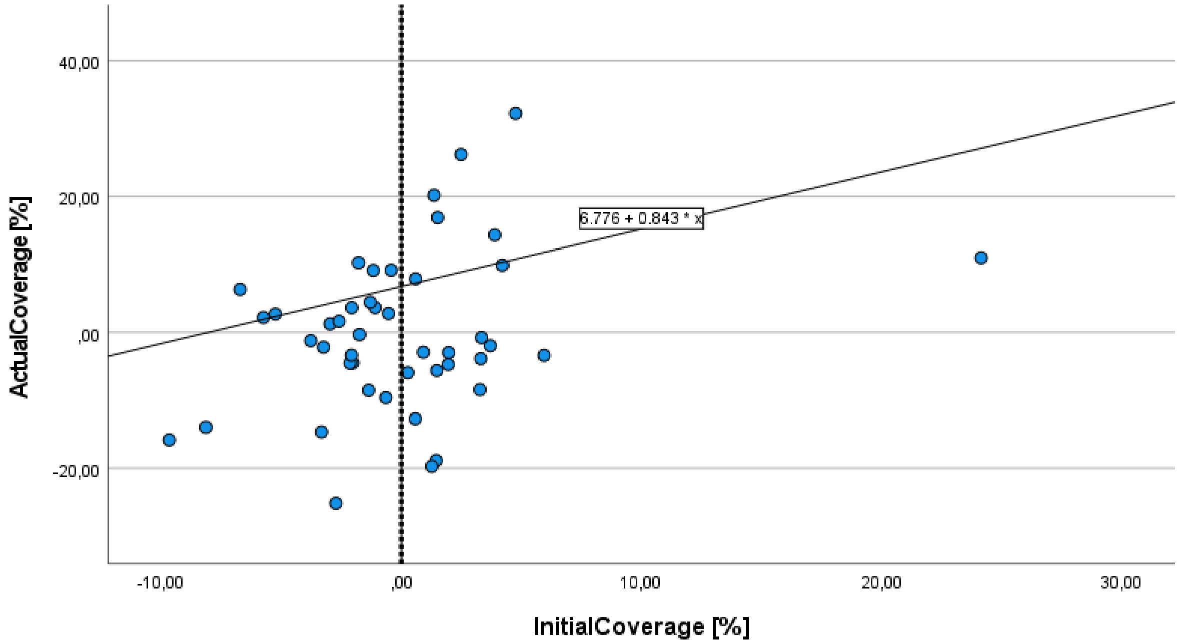

Figure 12: Partial regression plot ['Initial coverage' – 'Actual coverage']

IV2 Actual contract pric

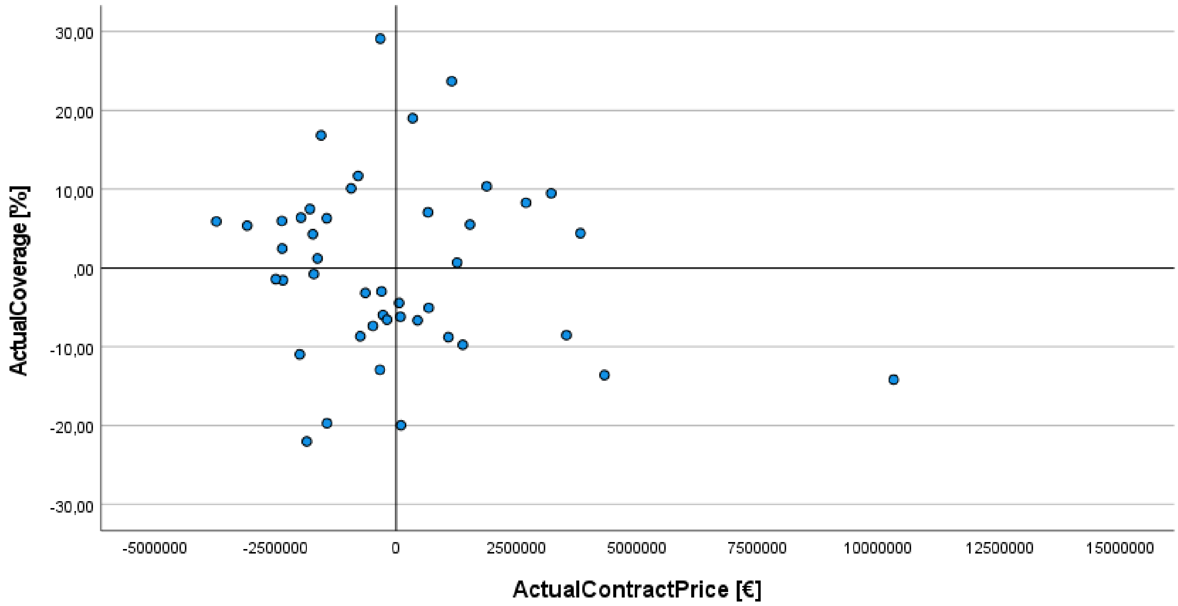

Figure 13: Partial regression plot ['Actual contract price' – 'Actual coverage']

IV3 Additional work

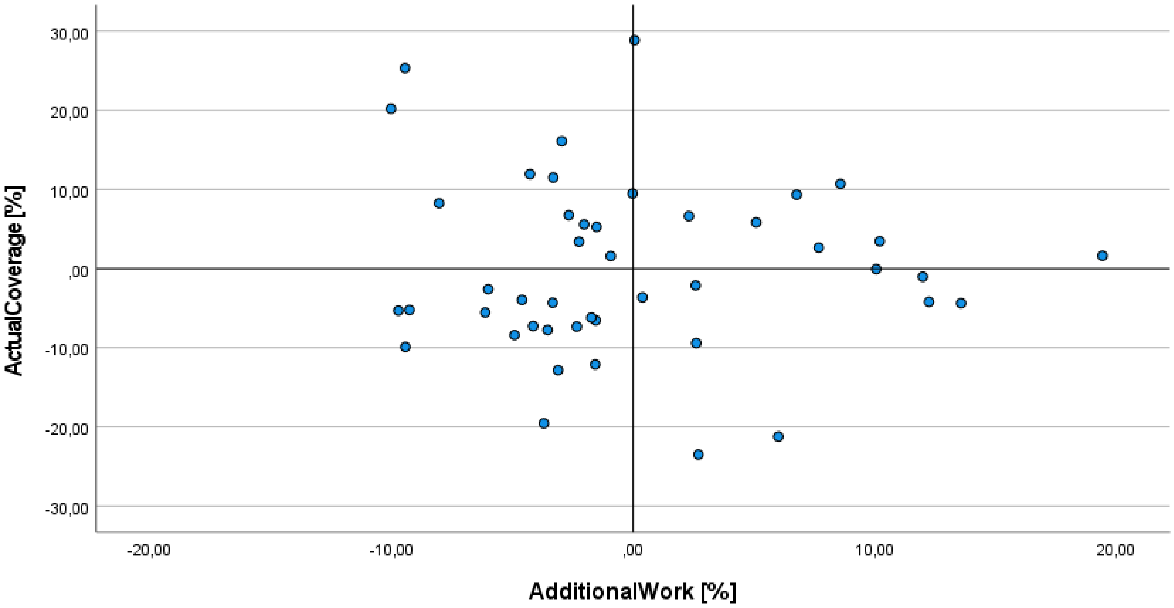

Figure 14: Partial regression plot ['Additional work' – 'Actual coverage']

IV4 Acquisition costs

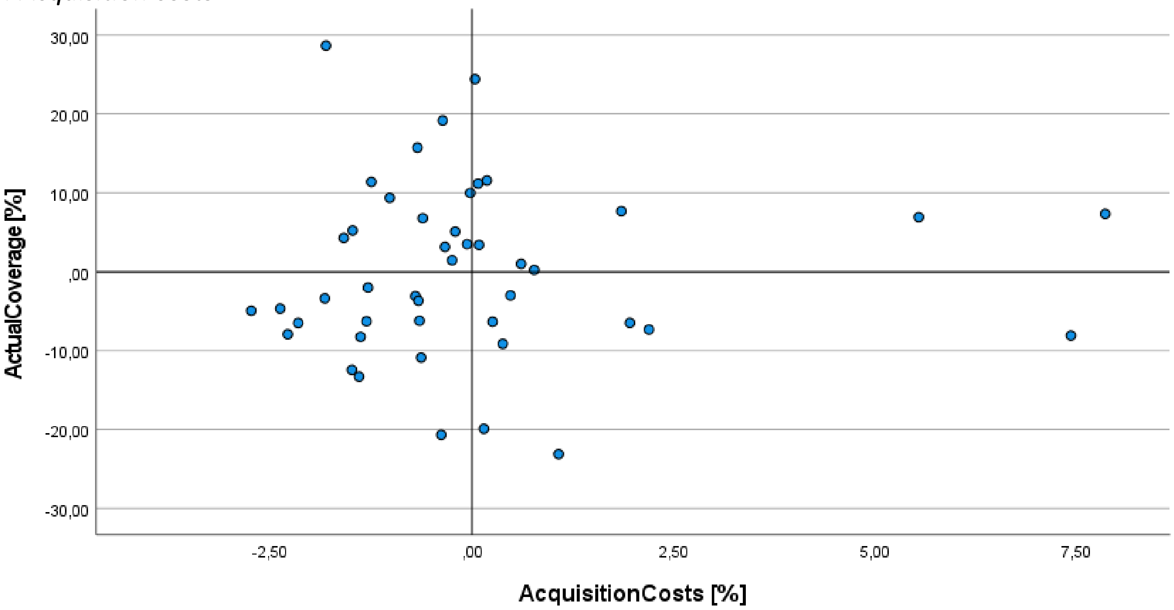

Figure 15: Partial regression plot ['Acquisition costs' – 'Actual coverage']

IV5 'Bouwteam'

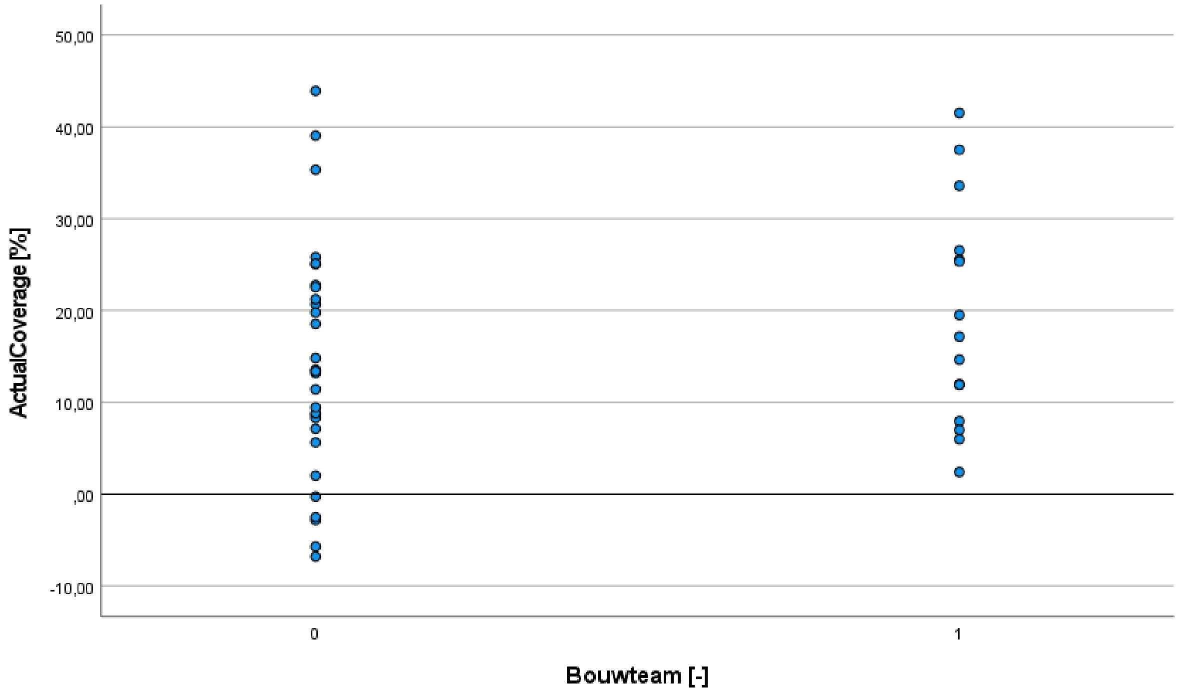

Figure 16: Partial regression plot ['Bouwteam' – 'Actual coverage']

$0 = NO$

$1 = YES$

IV6 Experience of project team

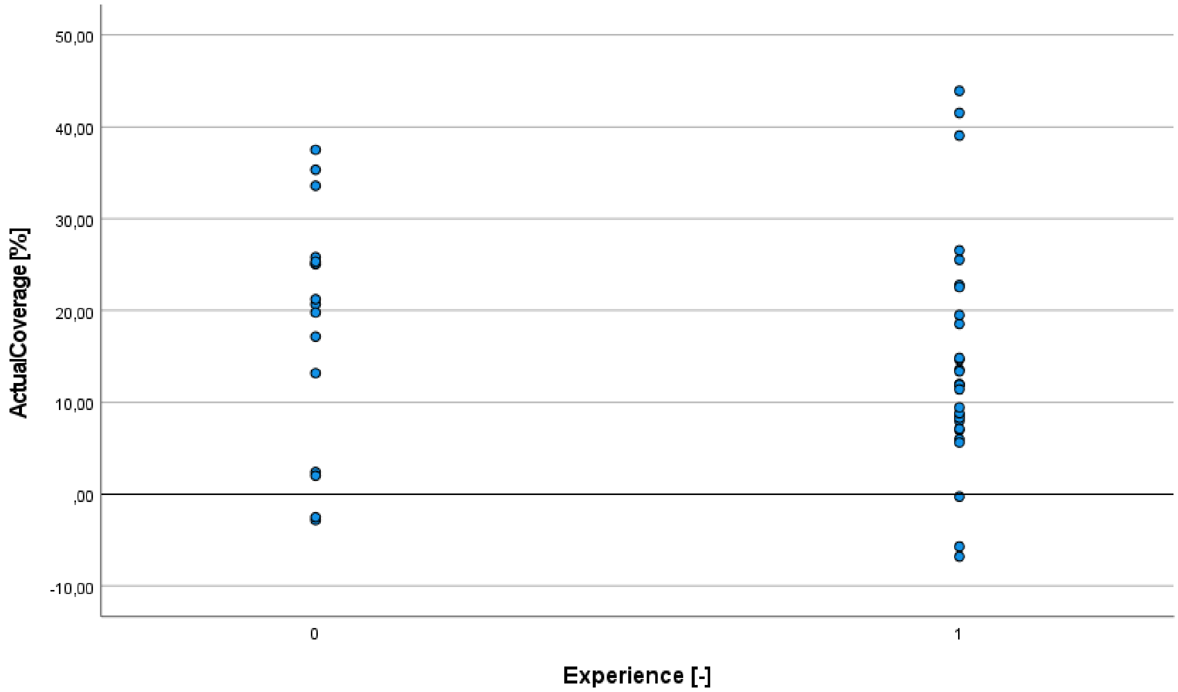

Figure 17: Partial regression plot ['Experience of project team' – 'Actual coverage']

$0 = Unique\ project\ type$

$1 = Similar\ type\ experiences$

IV7 Type of acquisition

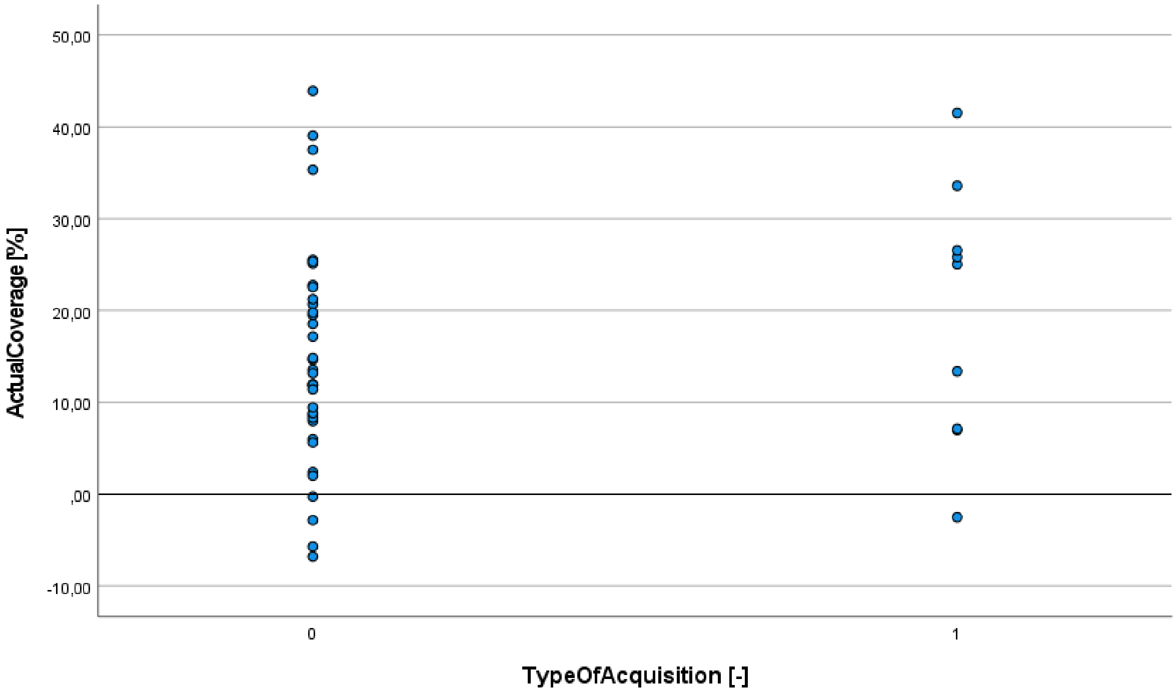

Figure 18: Partial regression plot ['Type of acquisition' – 'Actual coverage']

$0 = Nonpublic$

$1 = Public$

Appendix E. Slides of expert panel

Included as separate file (in Dutch): Appendix_E_Presentation_Expert_panel.pdf.

Appendix F. Transcription of expert panel

Date, time	27 June 2022, 16:30
Location	Hegeman office Nijverdal, and online
Duration	1h10m (70 minutes)

Attendees	**Organization**
Researcher (facilitator) (R)	University of Twente / Hegeman
Financial director (supervisor) (FD)	Hegeman
Managing director (MD)	Hegeman
Professor in construction management (P)	University of Twente
Project manager (PM)	External project management organization

Time interval (TI)		**Activity**
TI1	Min. 0 – 8	Not all attendees are familiar with each other. Therefore, everyone is shortly introducing themselves. On forehand, all attendees are notified about the research its problem statement, methodology, and results up till know. A recap on the notification doesn't raise any new questions.
TI2	Min. 9 – 17	P1. 'Project size is negatively correlated to project performance': According to PM, this is a valid proposition, considering a threshold after which the size of the project exceeds human imagination. MD supplements by that this can organization specific. For small organizations this threshold can already be at 1 million, whereas for large companies these can be very small, imaginable projects. Throughout the research, project size is defined by the contract price. P states that there is an important footnote on this definition: project complexity should be more accurate than contract price, of which is agreed in the panel.
TI3	Min. 18 – 35	P2. 'Additional works pressurize performance, since overhead costs are relatively high.': R provide closer notification on the proposition: "This proposition is raised because additional works in itself have a price much lower than the entire project contract price, however, they also need to walk through the entire business structure. MD starts: 'traditional clients live under the presumption that contractors favor additional works, but in fact we would like to know exactly what should be done on forehand, and for which price. Also, from traditional project structures, clients tend to be suspicious of contractors, which goes back to the large building construction fraud in the early 00's. In recent years this more and more changing towards a more collaborative field. This raises some confusion by PM if it is about additional works, of which there is discussion between client and contractor who should pay for the additional works, or that these are already fixed in the contract. For the matter of fact, it is agreed that both can be true in this case, so for practical reasons there is continued with a broad definition of

		'additional works'. FD contributes by stating that contractors live under the presumption that additional works can add up project performance in the end, since they can compensate for low margins on the contract price. The discussion that occurs, now touches two matters: P2 as already raised, and P4. 'Ealy collaboration with the client, eventually results in higher performance'. To maintain the current discussion, R already introduces P4. There is consensus that are strongly interdependent. Early collaboration and well-structured agreements will in the end lead to less discussion in unforeseen matters, such as additional works. Besides, collaboration is depending on the willingness of both parties to collaborate. In modern structures, which encourage collaboration, this is less the depending on the organizations itself, but more on the actual project team members. Their characters, competences and experience are very important in empathy in the other party, which is fundamental for collaboration. All in all, P2 remains inconclusive: it is about the type of additional work (foreseen or unforeseen), and competences of project team members to deal with these. About P4, everybody agrees that *late* collaboration is less productive and effective than *early* collaboration. However, the factor of project team competences in collaborating is even more important, but collaboration for both parties is in general a worthful investment.
TI4	Min. 36 – 42	P3. 'Contractors pay too few attention to the acquisition process.': According to MD this is certainly not the case at Hegeman. He believes enough, if not too much, time is spent in acquisition costs. However, the proposition raises a discussion in which there is consensus that for some issues or projects, too few time is spent in the acquisition phase, and for some too many. Again, this is related to project complexity, having the right employees at the right time and place, and competences and experience of those practitioners.
TI5	Min. 42 – 49	P5. 'Performance depends on project team experience': In the first seconds, everyone seems to agree with the proposition. After a few seconds, some nuances are suggested. Building upon earlier mentioned issues, it is depending on having the right people available at the right time. Also, it is the entire compilation, rather than having a lot of experienced members, or a lot of experience in the project team overall. FD provides an example of a speaker who was part of one of the best Volvo Ocean Racing teams. They gathered the best people all over the world for each position on the boat, however, they first acquainted right before the match, and their race became a disaster. This implies that you can have the best or most experienced people at each position, but that doesn't mean performance of the team can be great and can even fail.
TI6	Min. 50 – 57	P6. '(Medium)large contractors should stay away from public tenders': First R provides some elaboration on the choice of non-public and public tenders, which results from reliability issues for the regression analysis; further specification would lead to too much uncertainty and therefore exclusion of the variable. Paradoxical, PM states that public tenders provide more certainty to contractors than non-public projects assigned to them by clients. Since this raises some confusion, the elaborates that public tenders often have more certainty in continuation once they are

		broad to the market as a tender, whereas one-to-one projects between client and contractor are more uncertain in the way that you do not know when the client will assign you a new project. P continues that it also can provide certainty about your market position and competitiveness. MD and FD continue: it also depends on the certainty of your order book for upcoming year. If pressure on filling the portfolio is high, it can be a choice to assign for less favored projects. Also, they emphasize that (not completely) public tenders of governmental organizations, often provide more certainty than development projects of private clients. As MD states, they largely work for governmental organizations regarding healthcare, infrastructure and the Department of Defense, which are all fields which remain in operation, disregarded economic conditions of the country. As FD states, this is also depending on the organizational structure, whereas Hegeman is largely structured towards tendering, but other organizations could be stronger focused on own development and construction.
TI7	Min. 58 – 63	P7. 'Detailed scheduling is key for a good estimate of initial performance.': R starts with a notification on the proposition. From literature and explorative interviews to draw up IVs, scheduling turned out to be an important factor. Though, too few data points of this variable, led to deletion before the analysis. First, PM starts with questioning how 'detailed' should be defined, which is answered MD that this should be a weekly planning, which is in this context agreed to by R. All panel members highly value a detailed planning as the basis for a good estimate for performance. As stated, by MD, this is largely part of process management part of building organizations. He strongly believes the competences in the actual construction of works, but emphasizes that process related issues such as scheduling have become even more important. The panel agrees that there strong correlation between scheduling and initial performance assessment.
TI8	Min. 64 – 70	Wrap-up and model validation/suitability by means of two questions: Is the set as provided a complete view on project performance? How to account for interdependency and correlations between IVs?: MD starts with emphasizing the 'order book issue' as documented earlier, as an important matter that is hard to include in such an analysis, but plays an important role. Consulting the external panel members (P and PM) results in the following suggestions/remarks. They encourage to include the quality of project governance, validation and verification techniques, and post-assessments of projects. Though, a discussion with all members how such suggestions could be included in these kind of studies remains inconclusive, because of the complexity to implement such factors. As a result, it is emphasized that current structure (quantitative part followed by a qualitative part) suits these kind of studies. At last, they emphasize that, as also becomes clear from the propositions' discussions, they perceive strong correlations between factors that are included in the research. Though, this can't be directly derived from the correlation matrix in the regression output. --- Closing ---