AN EMPIRICAL STUDY ON THE CRITICAL SUCCESS FACTORS OF SMALL- TO MEDIUM-SIZED PROJECTS IN A SOUTH AFRICAN MINING COMPANY

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ABSTRACT

Projects that fail, for whatever reason, can impact negatively on society, organisations, and other stakeholders. A number of researchers have identified various critical success factors (CSFs) that can influence the outcome and success of a project. This research therefore aims to determine the CSFs that influence various success measures of small- to medium-sized projects at a South African mining company, Exxaro Resources' Grootegeluk Coal Mine. Other objectives of this research include determining the extent of the impacts of these CSFs on the different success measures of a project. The investigation suggests that there are correlations among CSFs, and that certain factors impact the outcome of projects far more than others. This research finds that the single most important CSF for small- to medium-sized projects is the selection of a competent project manager. The competent project manager is characterised by a group of interrelated CSF factors: good leadership, commitment, and learning from past experiences. Based on the research results, other CSFs are discussed and explored in order for recommendations to be made on how this mining company, and possibly other organisations, can achieve greater project success.

OPSOMMING

Mislukte projekte kan negatiewe impakte op die samelewing, organisasies en ander belanghebbendes hê. In die literatuur is daar reeds verskeie kritiese suksesfaktore geïdentifiseer wat die uitkoms en sukses van 'n projek kan beïnvloed. Hierdie navorsing mik daarna om die kritiese suksesfaktore wat verskeie suksesmaatstawwe van klein- tot mediumgrootte projekte by Exxaro Resources se Grootgeluk steenkoolmyn in Suid-Afrika beïnvloed. Nog 'n doelstellings van die studie sluit in die bepaal van die mate van die impak van hierdie kritiese suksesfaktore op die verskillende suksesmaatstawwe van 'n projek. Die ondersoek dui daarop dat daar korrelasies onder kritiese suksesfaktore bestaan en dat sekere faktore 'n baie groter invloed op die uitkoms van projekte het as ander. Die belangrikste kritiese suksesfaktor vir klein- tot mediumgrootte projekte is die aanstel van 'n bevoegde projekbestuurder. 'n Bevoegde projekbestuurder word gekenmerk deur etlike onderlinge kritiese suksesfaktore, naamlik goeie leierseienskappe, toewyding en ervaring. Ander kritiese suksesfaktore word op grond van hierdie studie bespreek en ondersoek om aanbevelings te maak oor hoe die mynboumaatskappy, en moontlik ander organisasies, verbeterde projek sukses kan behaal.

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1 INTRODUCTION

All organisations and project managers desire successful projects, some kind of 'secret recipe' that will result in low project failure rates. For decades researchers have been trying to identify the factors that lead to project success or failure (for example, the study by Pinto and Slevin [1]). These factors are commonly referred to in the literature as the critical success factors (CSFs) of projects. This research project is a case study on the factors that influence the success of small- to medium-sized projects at the Grootegeluk coal mine in the Limpopo Province of South Africa. This mine boasts the largest coal beneficiation complex in the world, and is the flagship of the diversified South African mining company called Exxaro. The level of annual investment in small- to medium-sized projects at Grootegeluk totals substantial amounts, and thus projects are key to the success and sustainability of the company. Recognising the important role projects can have in a company's success and sustainability, researchers have been trying for decades to determine the methodologies and CSFs that could influence the success of projects. Despite all the research, recommendations, and advances in project management, projects continue to fail. Pinto and Covin [2] found that this failure is because not all projects are similar when it comes to CSFs, and that these factors can also differ from organisation to organisation. This research aims therefore to identify the success factors at Grootegeluk coal mine, in order to improve the way projects are managed, not only ultimately to have a direct bearing on Exxaro financially, but also to contribute to the knowledge of project management. The reason that the focus is on small- to medium-sized projects is that 90 per cent of the projects at Grootegeluk are classified within this range of project size and, according to Pinto and Covin [2], there are different CSFs for different sizes and types of projects.

The main objectives of this study are to contribute to both research and practice by identifying project success factors, and to make recommendations to improve project performances at Exxaro Grootegeluk mine based on the the observations and outcomes of this research. In order to address the research problem, the following associated research questions are addressed:

- What are the project success factors associated with the small- and medium-sized projects at Exxaro Grootegeluk mine?
- What are the measures for project success?
- Are there common CSFs for the different success measures of projects?
- Which CSFs have the greatest impact on the success of a project?

2 THEORETICAL REVIEW AND FRAMEWORK

In the following section, the literature is briefly addressed and discussed in order to identify the measure of a project's success, to develop a list of CSFs, and to conceptualise these variables into a framework for the empirical analysis of this research. There are two components of project success: project success criteria, "which are the measures used to judge the success or failure of a project"; and project success factors, "which are the elements of a project which, when influenced, increase the likelihood of success" [3]. The project sizing model is briefly introduced in order to give a better reference point for the sample chosen in this study.

2.1 Defining the success measures in projects

In order to state what the CSFs are, it is important to define first what a successful project is. Steyn et al. [4] state that projects always have three-dimensional goals; time, cost, and quality. During the planning phase(s), these dimensions can be traded off against one another. Once the project has been approved for implementation, however, the project manager must be committed to completing the project within all three of these dimensions to achieve project success, unless an external factor forces a change in

these dimensions. Barber [5] refers to this as the "Iron Triangle" of cost, time, and quality. Pinto and Slevin [1] mention that projects are often rated as successful because they have achieved acceptable levels of the three-dimensional goals described by Steyn et al. [4] above, but that this can actually be partial and misleading. This is due to the fact that there are examples of projects that meet the budget and schedule constraints but do not meet the customer's requirements or needs. According to Dvir et al. [6], project success is subjective; your project manager may feel that the successful implementation of the project's planning objectives results in a successful project, whereas management may look at client satisfaction as a measure of success.

Cooke-Davies [7] on the other hand distinguishes between project success and project management success. Cooke-Davies [7] defines project success as achieving the overall objectives of the project, and project management success, which is the traditional measure as described by Steyn et al. [4], of performance against time, cost and quality. Young and Jordan [8] believe that project management success does not relate strongly to project success, and that top managers are not concerned with project management success unless a project is late, not on schedule, or over budget. Top managers, according to Young and Jordan [8], are concerned about project success and whether the project meets its stated benefits. Studies in the construction industry [9, 10] have also distinguished between project success and project management success.

It is evident from the literature that there is limited consensus among researchers on the definition of project success. Ahadzie et al. [11] agree that there is not much accord on the determinants of project success, and that these ambiguities make it difficult to monitor project outcomes.

The main intent of this empirical study is not to determine the success criteria of projects, but to determine the factors that result in project success or failure. Project failure is defined in this case as the loss of value to Grootegeluk. This loss of value will be determined from three points adapted from Tishler et al.[12], and the fourth point from Ahadzie et al. [11], which is specific to the mining industry. Their different points of view to measure success of a project are:

1. From the customers' point of view: meeting the functional and technical specifications.
2. From an operational point of view: meeting the budget and schedule.
3. Degree of business success from the project.
4. Degree of health and safety on the project.

These four points are similar to those from an extensive study by White and Fortune [13] on the criteria for judging project success. They evaluated the responses from 236 respondents over 16 different types of projects, on different aspects of those projects. Their criteria for measuring project success, as listed in Table 1, are ranked in order of importance. Their findings confirm the criteria selected to measure project success at Grootegeluk, as defined above from Tishler et al. [12] and Ahadzie et al. [11].

2.2 Critical success factors (CSFs) in projects

There have been a number of investigations to determine the CSFs of projects. Researchers have been exploring these factors since the 1960s, with the first being Rubin and Seelig [14] in 1967, in their article titled "Experience as a factor in the selection and performance of project managers". The literature on CSFs is both theoretical and empirical; the theoretical factors are more generalised while the empirical factors are discipline- or project-specific. Key findings from the literature in the past two decades will be discussed in chronological order where possible.

Table 1: Criteria used for measuring project success by White and Fortune [13]

Criteria	*Rank*
Meets client's requirements	1
Completed within schedule	2
Completed within budget	3
Meets organisational objectives	4
Yields business and other benefits	5
Causes minimal business disruption	6
Meets quality and safety standards	7
Other criteria	8

Pinto and Covin [2] found that projects are not all similar when it comes to CSFs, and that care must be taken to consider these differences when applying CSFs. According to them, there are basic similarities within project types and classes, but there are characteristic differences between the factors considered to be critical for the success of a project, for different types of projects. In their research, they discovered that CSFs vary and change as projects go through the different stages in their life-cycles (conceptual, planning, execution, and termination), independent of the type of project. Pinto and Covin [2] also stated that the CSFs determined on a company-by-company basis (as will be in this case study on Grootegeluk) that they may be so specific that they will not be applicable or useful in other company settings. However, the research by Pinto and Slevin [15] addressed this issue through their investigation of CSFs across a number of organisations. They identified fourteen common factors (project mission, communication, trouble-shooting, characteristics of the project's team leader, etc.) related over the range of companies that were used by Pinto and Covin [2] in their research.

Belassi and Tukel [16] developed a new framework to determine the critical success or failure factors in projects. They argued that the problem with CSFs in the pre-1996 literature is that, when researchers determined the critical factors of a project, they ignored the project's characteristics, the characteristics of the team members, and factors external to the project. Typical examples include the weather in construction projects, or the timeliness of a new product reaching the market. Even though these factors cannot be controlled by either the project manager or management, they are still critical to the success of the projects and need to be considered. Belassi and Tukel [16] recognise that it is difficult to identify all the possible critical factors or group of factors that influence particular projects, because of the diversity of projects and range of CSFs. CSFs are grouped as follows:

1. Factors related to the project;
2. Factors related to the project manager and team members;
3. Factors related to the organisation; and
4. Factors related to the external environment

The advantage of grouping the factors is that it will help to identify whether the success of a project is related to the project manager, the project, and/or to the external environment. According to Fortune and White [17], a criticism of CSFs in the literature is that researchers have focused on individual factors, and not on the importance of the inter-relationships between the factors. By grouping inter-related factors, this short-coming is addressed.

The literature on CSFs has highlighted that there are many recommendations and points of view on which critical factors may influence the outcome of a project. Fortune and White

[17] conducted a detailed analysis of 63 publications that address CSFs. From their review, they noted that the three most important CSFs are:

1. Top-management support (supported by a more recent study by Young and Jordan [8]);
2. Clear and realistic objectives; and
3. Efficient planning.

The majority of the literature cited by Fortune and White [17] does not attempt to relate the CSFs directly to the project success measures; this is a criticism, as perceptions of project management success across organisations may differ. For some organisations, it might be more important that a project is completed on time than that it is completed within cost; thus this project will be considered a success. This is typical in the military, where the time it takes to deliver certain projects to war-afflicted areas outweighs, by far, the cost factors or the budget of the project. In the mining industry, for example, no matter how well a project meets its time, cost, and quality objectives, if there is a fatality on the project, it is considered a failure.

What is noticeable from the factors identified by Fortune and White [17] is that the effects of project management techniques, administration support, and human resource competency of project managers are not really addressed. With the fast development of project management techniques and the growth of technology and project tools, project administration has become more encompassing and complex [5]. As a result, a project manager in the future should have well-developed skills that include being adaptable, a quick learner, and a good communicator. This continuous evolution of project management is changing the skills expected of effective project managers. So companies need continually to benchmark their methodologies and ways of carrying out projects. Research has shown vast differences between leading companies and average companies in how they conduct particular activities. Barber [5] elaborates on this, arguing that benchmarking project management can significantly improve the performance of projects in organisations. In the 'Project Management Body of Knowledge' (PMBOK) [18] by The Project Management Institute, a number of competencies that a project manager should master are identified. Project managers need to have the project management knowledge, as well as the technical skills, to master their projects. The competencies outlined in the PMBOK include:

- scope, time, and cost management;
- human resource management;
- communication management;
- risk management; and
- quality and contract management.

According to El-Sabaa [19], a project manager is required to have extensive cross-functional experience. He/she also needs a basic understanding of the competencies mentioned in the PMBOK in order to be efficient. El-Sabaa's [19] findings emphasise that a project manager's competency in human resource management is more important than a technical competency – something that does not come out clearly from the 63 publications cited by Fortune and White [17].

Because projects are unique, Barber [5] argues that management practices are also unique – an issue that may result in benchmarking challenges. In other words, because of this uniqueness, there is no direct comparison that can be used between projects, which explains the lack of consensus in researchers' findings on the factors that lead to successful projects. In the findings by Belassi and Tukel [16], however, there are distinct relationships between the success of most projects and the involvement of the project manager's performance on the job, the technical background of project members, and the team's commitment to the project. They found that environmental factors also influenced projects, but that this influence may be minimal in small- to medium-sized projects.

2.3 Defining project size in Exxaro

Projects are classified in some organisations according to their size. For the purposes of this research, it is imperative that the criteria to define the size of projects in Exxaro are discussed, in order for others to draw parallels with their definitions and those of Exxaro. Exxaro has five different class-sizes of projects: mini, small, medium, large, and mega. The aim of this research is to determine the factors that result in project success or failure in mini-, small-, and medium-sized projects at Grootegeluk. All projects are scored out of 100 points, determined by six project characteristics with their associated weight factors, as illustrated in Table 2.

Table 2: Project characteristics used to define project sizes in Exxaro (Source: adapted from Exxaro-Wide-Project-Management standards documentation, April 2012 [20])

Point	Description	Weight
1	Financial resources	40
2	Number of team members	10
3	Number of departments/processes represented on the project team	15
4	Complexity of the technology	10
5	Time frames	10
6	Level of impact	15
	Total	**100**

The total point (score) determined from the six project characteristics was used in five possible categories of project sizes (see Figure 1), and in turn used in the questionnaire design. Datasets for the first three categories (mini-, small-, and medium-sized projects) were chosen for further analysis.

Figure 1: The Exxaro project-size categories based on scores determined in Table 2.

3 CONCEPTUAL MODEL AND RESEARCH METHODOLOGY

3.1 Conceptual model

The literature review proved that there are many different findings and points of view when it comes to the factors in projects that will lead to project success or failure, depending on how they are managed or enforced. The CSFs are based on Fortune and White's [17] review of 63 publications. The grouping of the CSFs in Table 3, which draws on Belassi and Tukel's [16] four categories of CSFs, is used as a guideline to determine whether certain factors are inter-related and can be combined into simpler factor groups. The results from the survey were analysed for internal consistency using the Cronbach's alpha reliability coefficient. The factor groups with alpha values greater than 0.6 are assumed to have acceptable internal consistency, while those greater than 0.8 are assumed to have strong inter-relationships. The factors known as 'competent project manager', 'applying project methodologies', and a project team's 'technical background' all have Cronbach alpha greater than 0.8, which means that these factors can represent

the same theoretical construct. The factors within the groups 'project front end loading' and 'organisational support' have acceptable internal consistency because their Cronbach alpha is greater than 0.6. The factors in the other groups cannot be grouped due to low internal consistencies, and have thus been labelled as individual CSFs (see Table 3). The findings for CSF 1 (competent project manager) are aligned with the views of Barber [5], who stated that a project manager should have well-developed skills such as being adaptable, a quick learner, and a good communicator. According to CSF 1, to be defined as a competent project manager, one must have the following attributes: a good leader; a good communicator; committed; and able to learn from past experiences. The same deductions can be made for the other grouped CSFs, such as 'project team technical background', where a successful team is defined as one that is suitably skilled, qualified, shows commitment, and communicates well. It is thus important to consider all the inter-related factors when selecting a project manager, project team, project methodologies, and the means of conducting project front-end loading.
The successes of the projects were measured against the criteria established from the literature review. These criteria were obtained from a combination of the factors defined by Tishler et al. [12] and Ahadzie et al. [11]. The four success measures used in this research are:

1. Meeting the functional and technical specifications of the project;
2. Meeting the budget of the project;
3. Meeting the schedule of the project; and
4. Degree of health and safety on the project.

3.2 Research methodology

In the literature, a number of authors, including Adhazie et al. [11], White and Fortune [13], and Dvir et al. [6], used the survey questionnaire method to obtain data on CSFs. The advantage of this method is that it allows anonymity and gives respondents the freedom to express their point of view. According to Welman et al. [21], responses in survey questionnaires are the most honest ones. The questions incorporated the CSFs listed in Table 3. Respondents, who consisted of project managers and project team members, first had to rate the success of the project based on the success measures determined in the literature review, and then the actual occurrence of each CSF in Table 3. A Likert-type scoring system was used to determine the magnitude of the project success measures and CSFs. The majority of the project managers currently employed at Grootegeluk have been in service for at least three years; thus the projects that were analysed for this study were obtained from the project list for the years 2009, 2010, and 2011. All the projects listed in these years, with project managers still employed in Exxaro, were sized according to the Exxaro sizing-model discussed earlier. The projects that are medium-sized and smaller were considered in this research.

From the historical project databases, about 120 people (project managers and team members) worked for projects in Grootegeluk over those three years. All the respondents in this research are current employees, and employees who have left the company were excluded. Although the sample chosen may pose some bias in the results, the sample has experienced both successful and unsuccessful projects, and the results will therefore not be biased only towards successful or unsuccessful projects. For a confidence level of 95 per cent and confidence interval of 10 per cent, a sample size of 54 was needed. Expecting a response rate of 60 per cent, 85 questionnaires were randomly distributed. There was an excellent response rate: a total of 70 completed questionnaires were returned, resulting in a confidence interval of 7.7 per cent at a 95 per cent confidence level.

Independent samples t-tests were performed in order to associate the factors with project success measures. To identify the most important CSFs, regression models were developed and analysed. CSFs that have the highest and significant beta values in the models are considered to have the highest impact on project success.

Table 3: CSFs identified, grouped, and tested for internal consistency

FACTOR GROUPS		FACTORS	Cronbach's alpha (α)
Project Manager			
CSF 1	Competent project manager	Good leadership	0.87
		Good communication/feedback	
		Commitment	
		Applies lessons learnt from past experiences	
CSF 2	Applying project methodologies	Strong detailed plan kept up-to-date	0.846
		Correct choice/past experience of project management methodologies/tools	
Project Team			
CSF 3	Technical background	Skilled/suitably qualified, sufficient staff/team	0.872
		Good communication/feedback	
		Commitment	
CSF 4	Project resources	Sufficient/well-allocated resources, No vacancies	0.152
CSF 5		Project support in administration	
Project			
CSF 6	Project complexity	Proven/familiar technology	0.071
CSF 7		Clear, realistic objectives	
CSF 8	Project front-end loading	Strong business case, sound basis for project	0.612
		Correct cost estimates/budget	
		Technical review	
Organisation			
CSF 9	Organisational support	Support from senior management	0.59
		Organisational adaptation/culture/structure	
		Project sponsorship/champion	
		Training provision	
External Factors			
CSF 10	Stakeholders and other factors	User/client involvement	0.213
CSF 11		Good performance by suppliers/contractors/ consultants	
CSF 12		Legislation	
CSF 13		Environmental influences	
CSF 14		Political stability	

4 RESULTS

4.1 Descriptive statistics: Project success measures and CSFs

The dependent variables are the success measures of projects, and were defined earlier in the literature review. The frequency count results from the survey are depicted in

Table 4 for each one of the four success measures. Using the frequency counts, two independent groups were identified, with approximately equal sizes for independent t-test analysis. The importance of the t-test is to assess whether the means of the CSFs of the two groups are statistically different from each other, in order to determine the significance relationship between CSF and the success measure. For success measure 2, group 1 is defined as being 'within the budget', and Group 0 is defined as 'exceeding the budget'. For success measure 3, group 1 is defined as 'completing a project within 15 per cent of the planned schedule', and group 0 is defined as 'completing a project more than 15 per cent over the planned schedule'. Because the scale variance in the data is too large to get two equal sample sizes for success measures 1 and 4, only the CSFs influencing success measures 2 and 3 will be investigated further in this paper.

Table 4: Frequency counts of the project success measures

Dependable variables		Frequency counts (%)	Grouping
Success measure 1: Meeting the functional and technical specifications of the project	< 20% compliant	0.00	Invalid
	21-40% compliant	5.80	
	41-60% compliant	8.70	
	61-80% compliant	24.64	
	81-100% compliant	60.87	
Success measure 2: Meeting the budget of the project	>26% over budget	8.70	Group 0
	16-25% over budget	8.70	
	10-15% over budget	13.04	
	1-10% over budget	14.49	
	Within the planned budget	55.07	Group 1
Success measure 3: Meeting the schedule of the project	>26% over the planned schedule	31.88	Group 0
	16-25% over the planned schedule	13.04	
	10-15% over the planned schedule	11.59	Group 1
	1-10% over the planned schedule	21.74	
	Within the planned schedule	21.74	
Success measure 4: Degree of health and safety (HS) on the project.	Fatality or more than 1 lost-time injury	0.00	Invalid
	1 lost-time injury or more than 1 minor injury	1.43	
	1 minor injury	2.86	
	1 HS incident	4.29	
	100% HS achieved	91.43	

Means and standard deviations associated with the grouped CSFs are given in Table 5. A five-point Likert scale was used. There are no concerns about the data, as in all cases the standard deviation is less than the mean. The respondents rate the CSFs based on actual occurrences and not on what they perceive to be important. Thus one cannot deduce what the most important factor is from this table by looking at means and standard deviations. The association between a CSF and the success measure can be examined by using independent samples t-tests. The significance and the importance of the CSFs are

determined by the influence they have on the change in the success measures, which is determined by conducting the regression analysis.

Table 5: Means and standard deviations of the CSFs

Variables		Mean	SD
CSF 1	Competent project manager	3.904	0.944
CSF 2	Applying project methodologies	3.331	1.158
CSF 3	Technical background of the team	3.951	0.864
CSF 4	Sufficient/ well-allocated resources / No vacancies	4.220	1.063
CSF 5	Project support in administration	2.780	1.553
CSF 6	Proven/ familiar technology	2.490	1.113
CSF 7	Clear, realistic objectives	4.150	0.950
CSF 8	Project front end loading	3.833	0.789
CSF 9	Organisational support	3.669	0.663
CSF 10	User / client involvement	3.790	1.100
CSF 11	Good performance by suppliers/contractors and consultants	3.740	1.141
CSF 12	Legislation	2.100	1.199
CSF 13	Environmental influences	1.660	0.956
CSF 14	Political stability	1.150	0.432

4.2 Independent samples t-test results

Table 6 shows the independent samples t-test results of the two groups for each of the success measures: meeting the budget and meeting the planned schedule. For success measure 2 (meeting the budget), the group means for CSFs 1, 2, 3, 8, 11, 12, and 14 in group 1 (meeting the budget), are significantly higher than those in group 0 (not meeting the budget). In other words, to increase the chances for a project to meet its budget, the project manager needs to be competent with the necessary skills defined in Table 3: apply project methodologies correctly, and have a project team with a strong technical background. There also needs to be adequate front-end loading to ensure that the scope and cost estimates are at a higher level before obtaining the approval for funds. It is also clear from Table 6 that selecting the correct suppliers and contractors is vital to a project meeting its budget, and that this needs to be considered when evaluating and selecting such people. It should be noted that the mean differences between group 0 and group 1 of each of these above-mentioned factors are higher, except for CSFs 12 (legislation) and 14 (political stability). This means that the team members and project managers whose projects were within budget rated the influence of these factors lower than those who did not achieve their budget. What can be deduced from this is that legislation and political issues related to these projects hindered their budgets, and that those projects that finished within budget were not influenced by, or did not experience, the effect that these factors could have on a project. CSFs 1, 2, 3, 8, and 11 can all be influenced by senior managers, the project manager, and team members when planning and executing a project, and must therefore be deliberated. CSFs 12 and 14 have an impact on the project, but are not always avoidable or are there by choice, and thus have to be noted when budgeting for a project. Should these two CSFs risk the success of a project, their associated risks need to be identified and mitigated if possible.

For success measure 3 (meeting the planned schedule), CSFs 1, 2, 3, 4, 7, 8, 9, 11 ,and 12 all have an impact on whether a project will meet the planned schedule or not. For this success measure, all the group means of the CSFs, except for CSF 12, are larger in Group 1 (meeting the planned schedule) than in Group 0 (not meeting the planned schedule). In

addition to CSFs that influenced success measure 2, CSFs 4 (sufficient project resources), 7 (clear realistic objectives), and 9 (organisational support) also impact on the chances of a project meeting its planned schedule. Projects need to be well-staffed to ensure that resources are not over-loaded, and that the scope is achievable within the planned schedule. A fully-staffed project team costs money, and thus will negatively influence a project's budget, as no potential savings will be realised if there were vacancies; but the more manpower and technical expertise there is, the higher the probability that the planned work will be completed on time. Clear, well-defined objectives also impact this success measure, because this will reduce the likelihood of variations or 'scope-creep' taking place. The highest-rated CSF, from the Fortune and White's [17:55] analysis of the 63 publications, was 'top management support', which was found also to be a CSF (i.e. CSF 9) that influences the schedules of Grootegeluk's projects. Management is sometimes unaware of the impact they may have on the success of a project, and these findings of the significance of CSF 9 (organisational support) emphasise that they do.

Table 6: Independent t-tests on success measures: Meeting the budget and meeting the planned schedule

Variables	Meeting the budget					Meeting the planned schedule				
	Group 0 Not within budget (N = 31)		Group 1 Within budget (N = 38)		T –test[a] p-value[b]	Group 0 Not within schedule (N = 31)		Group 1 Within schedule (N = 38)		T -test[a] p-value[b]
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
CSF 1	3.54	1.09	4.21	0.68	-0.67**	3.43	0.93	4.50	0.54	-1.07***
CSF 2	3.06	1.17	3.55	1.11	-0.49*	2.86	1.11	3.93	0.92	-1.08***
CSF 3	3.73	0.99	4.16	0.71	-0.43**	3.57	0.84	4.48	0.60	-0.91***
CSF 4	4.00	1.21	4.42	0.89	-0.42	3.87	1.15	4.70	0.70	-0.83***
CSF 5	2.81	1.42	2.76	1.67	0.05	2.76	1.44	2.80	1.71	-0.04
CSF 6	2.65	1.22	2.37	0.99	0.28	2.44	0.99	2.57	1.25	-0.13
CSF 7	3.90	0.94	4.37	0.91	-0.47	3.82	1.02	4.60	0.62	-0.78***
CSF 8	3.57	0.90	4.05	0.61	-0.48**	3.52	0.76	4.24	0.61	-0.72***
CSF 9	3.52	0.70	3.76	0.63	-0.24	3.40	0.63	3.98	0.58	-0.58***
CSF 10	3.74	1.21	3.87	1.01	-0.13	3.77	1.16	3.87	1.04	-0.10
CSF 11	3.45	1.29	3.97	0.94	-0.52*	3.31	1.10	4.30	0.92	-0.99***
CSF 12	2.45	1.26	1.84	1.08	0.61**	2.49	1.28	1.63	0.89	0.86**
CSF 13	1.77	0.99	1.55	0.92	0.22	1.69	0.98	1.60	0.93	0.09
CSF 14	1.26	0.58	1.05	0.23	0.210*	1.21	0.522	1.07	0.25	0.14

a. Mean difference between two groups

b. * Mean difference is significantly different at p<0.05

** Mean difference is significantly different at p<0.01

*** Mean difference is significantly different at p<0.001

4.3 Multivariate regression analysis

The CSFs that have an influence on the success measures of projects at Grootegeluk were determined from the t-tests, as discussed earlier. The importance of doing a multivariate regression analysis is to determine which CSFs actually have the greatest influence on the success measures (as dependent variables (DV)). The models listed in Table 7 and Table 8 were estimated by conducting Ordinary Least Square-based

Hierarchical Regression Analyses. The CSF variables for the various CSF groups (Project Manager Group = CSF 1 and CSF 2) were entered into the models in steps to determine what impact these variables have on the success measure, by examining the beta value and ΔR^2 of the CSFs.

The regression models are shown below:

Model 1: $DV=\beta_0+ \beta_1(CSF\ 1)+ \beta_2\ (CSF2)+\varepsilon$

Model 2: $DV=\beta_0+ \beta_1(CSF\ 1)+ \beta_2\ (CSF2)+ \beta_3(CSF\ 3)+ \beta_4\ (CSF4)+ \beta_5\ (CSF\ 5)+\varepsilon$

Model 3: $DV= \beta_0+ \beta_1(CSF\ 1)+ \beta_2\ (CSF2)+ \beta_3(CSF\ 3)+ \beta_4\ (CSF4)+ \beta_5\ (CSF\ 5)+ \beta_6\ (CSF\ 6)+ \beta_7\ (CSF\ 7)+ \beta_8\ (CSF\ 8)+\varepsilon$

Model 4: $DV= \beta_0+ \beta_1(CSF\ 1)+ \beta_2\ (CSF2)+ \beta_3(CSF\ 3)+ \beta_4\ (CSF4)+ \beta_5\ (CSF\ 5)+ \beta_6\ (CSF\ 6)+ \beta_7\ (CSF\ 7)+ \beta_8\ (CSF\ 8)+ \beta_9\ (CSF\ 9)+ \varepsilon$

Model 5: $DV= \beta_0+ \beta_1(CSF\ 1)+ \beta_2\ (CSF2)+ \beta_3(CSF\ 3)+ \beta_4\ (CSF4)+ \beta_5\ (CSF\ 5)+ \beta_6\ (CSF\ 6)+ \beta_7\ (CSF\ 7)+ \beta_8\ (CSF\ 8)+ \beta_9\ (CSF\ 9)+ \beta_{10}\ (CSF\ 10)+ \beta_{11}\ (CSF\ 11)+ \beta_{12}\ (CSF\ 12)+ \beta_{13}\ (CSF\ 13)+ \beta_{14}\ (CSF\ 14)+\varepsilon$

Table 7: Regression analysis for the success measure: Meeting the planned budget

Variables		Dependent Variable: SM2 - Meeting the budget of the project				
		Model 1	Model 2	Model 3	Model 4	Model 5
Constant		1.423**	1.423*	0.352	-0.057	1.146
Independent Variables						
CSF 1	Project Manager	0.5***	0.469*	0.32*	0.295*	0.237
CSF 2		-0.067	-0.41	0.039	0.015	-0.108
CSF 3	Project Team		0.005	-0.174	-0.203	-0.108
CSF 4			0.029	-0.126	-0.143	-0.224
CSF 5			0.048	-0.083	-0.053	-0.04
CSF 6	Project			-0.1	-0.123	0.013
CSF 7				0.201	0.184	0.102
CSF 8				0.413***	0.413***	0.425***
CSF 9	Organisation				0.14	0.082
CSF 10	External Factors					0.191
CSF 11						0.129
CSF 12						-0.169
CSF 13						-0.154
CSF 14						-0.235**
R^2		21.10%	21.40%	38.30%	39.50%	50.80%
ΔR^2		21.10%	0.20%	16.90%	12.00%	11.40%
F- Value		8.708***	3.372***	3.995***	3.715***	3.581***
F- Value Change		8.708***	0.065	3.968***	1.116	2.401**

*p < 0.10; **p < 0.05; ***p < 0.01

In Table 7, all the models have statistically highly-significant F-values ($p < 0.01$), meaning that the data fits regression models exceptionally well. The CSF with the greatest influence on whether a project at Grootegeluk will meet the budget of the project is CSF 1 (beta value of 0.5, $p<0.01$), which is 'having a competent project manager'. This CSF accounts for 21.1 per cent of variation in the dependent variable (meeting project budget). Other highly-significant CSFs that contribute are CSF 8 (project front-end loading) and CSF 14 (politics – which is project-specific). These CSFs account for about

16.9 per cent and 11.4 per cent variation respectively of the success measure. The other identified CSFs 2, 3, 11, and 12 are associated with this success measure (from the independent samples t-test results), but do not have the causal effect that CSF 1, 8, and 14 have.

Table 8: Regression analysis for the success measure: Meeting the planned schedule

Variables		Dependent Variable: SM3 - Meeting the planned schedule of the project				
		Model 1	Model 2	Model 3	Model 4	Model 5
Constant		-1.396**	-2.147**	-2.844***	-2.883**	-2.26**
Independent variables						
CSF 1	Project Manager	0.463***	0.204	0.16	0.158	0.164
CSF 2		0.266**	0.3**	0.361**	0.359**	0.299**
CSF 3	Project Team		0.365**	0.251*	0.249*	0.208
CSF 4			-0.002	-0.091	-0.093	-0.136
CSF 5			-0.123	-0.179	-0.177	-0.127
CSF 6	Project			0.053	0.051	0.175
CSF 7				0.129	0.128	0.146
CSF 8				0.169	0.169	0.135
CSF 9	Organisation				0.011	-0.017
CSF 10	External Factors					0.003
CSF 11						0.128
CSF 12						-0.228**
CSF 13						0.073
CSF 14						-0.072
R^2		44.20%	52.50%	56.30%	56.30%	61.40%
ΔR^2		44.20%	8.30%	3.80%	0.00%	5.20%
F- Value		25.761***	13.694***	8.29***	7.335***	5.521***
F- Value Change		25.761***	3.594**	1.254	0.1	1.391

*p < 0.10; **p < 0.05; ***p < 0.01

The models in Table 8 all have highly-significant F-values, as with the models in Table 7. This means that the data also fits the regression models extremely well. The most significant CSFs contributing to whether a project at Grootegeluk finishes within the planned schedule are CSF 1 (competent project manager) and CSF 2 (applying project methodologies), with significant beta values of 0.463 and 0.266 respectively. Both CSFs account for 44.2 per cent of variation in the dependent variable (meeting project schedule). In model 2, CSF 3 (project team technical background) has a significant beta coefficient of 0.365 ($p < 0.05$) that is responsible for 8.3 per cent variation in the project schedule variable. In model 5, CSF 12 (legislation) has a significant and negative beta value of 0.0228 ($p<0.05$), and accounts for 5.2 per cent of the variation of the dependent variable. Overall, it is only CSFs 1, 2, 3, and 12 that have causal effects on the dependent variable (meeting the planned schedule of the project).

5 CONCLUSIONS AND RECOMMENDATIONS

The objectives defined for this research were achieved to a large extent. There are findings for all three of the study objectives, and some conclusions and recommendations can be drawn. The main conclusions are as follows:

- Certain project factors show internal consistency, and can be classified into groups. Table 3 is a summary of the 25 factors condensed into 14 CSFs.
- Not all of the classified CSF groups were critical to the success of projects. For both success measures 'meeting the budget' and 'meeting the planned schedule', the CSFs listed below in Table 9 were associated with the success measures, significantly based on the independent samples t-tests. CSFs 1, 2, 3, 8, 11, and 12 were common to both success measures.

Table 9: Summary of significant CSFs

Critical Success Factors (CSFs)		Success in budget	Success in schedule
CSF 1	Competent project manager	Yes	Yes
CSF 2	Applying project methodologies	Yes	Yes
CSF 3	Technical background of the team	Yes	Yes
CSF 4	Sufficient/well-allocated resources, No vacancies	No	Yes
CSF 7	Clear, realistic objectives	No	Yes
CSF 8	Project front-end loading	Yes	Yes
CSF 9	Organisational support	No	Yes
CSF 11	Good performance by suppliers/ contractors/consultants	Yes	Yes
CSF 12	Legislation	Yes	Yes
CSF 14	Political stability	Yes	No

The CSFs with the greatest influence on projects at Grootegeluk were determined from the multivariate regression analysis. The CSFs with the most influence on a project meeting its budget are, in descending order:

1. CSF 1 - Competent project manager
2. CSF 8 - Project front-end loading
3. CSF 14 - Political stability

The CSFs with the most influence on a project meeting its planned schedule are, in descending order:

1. CSF 1 - Competent project manager
2. CSF 2 - Applying project methodologies
3. CSF 3 - Technical background of the team

The research findings highlight that in order for Grootegeluk to improve the way projects are managed, there needs to be a strong focus on selecting competent project managers who demonstrate project management skills, and who are committed. CSF 1 was clearly the most significant and most influential factor in the success of a project. It is also important that project methodologies such as the PMBOK are followed by the project team. These project teams should also be carefully selected, and have the right technical skills to execute the projects successfully. The front-end loading of projects should also be comprehensively done to the industry's defined standards.

Exxaro has number of initiatives in place related to the CSFs identified as being significant in the paper. The initiatives are as follows:

1. To ensure project management (project manager and team) competence, a strict development and mentoring programme has been put in place. Project managers receive internal and external training on a continual basis. The internal training comprises computer-based courses on the PMBOK, and the external training is supported for Prince 2, PMBOK, Universities (Masters), and PMP certification. Team members receive similar training based on their job profile.
2. Project managers and teams are allocated to projects that relate to their key strengths and competencies (e.g., a project manager with a history of civil projects is allocated to similar civil projects).
3. Exxaro has recently developed key knowledge areas related to its mining projects, and developed the methodology "Exxaro Wide Project Management" (EWPM), which is derived from the PMBOK and Prince 2. This is to ensure that Exxaro's mining projects apply the correct project management tools and techniques and adhere to internal governance. This is supported by the software package Microsoft Enterprise Project Management (EPM). EPM provides the project manager and teams with the correct processes, templates, and tools related to the EWPM methodology. The EWPM requires adequate front-end loading for all projects, with specific deliverables for the different phases of projects in Exxaro. This initiative was begun in 2012, and is continually improved upon. Since implementing this initiative, there has been a noticeable improvement in project success rates at Exxaro.
4. Regular guidance and audits on the adherence to EWPM and use of the EPM system. This will ensure that the project manager and team apply the correct project methodologies.
5. Benefits-tracking and lessons learnt. All projects at closure will involve representatives from the project team, the client team, and technical review team to address the lessons learnt related to each success measure and key performance areas of the project. The lessons learnt will be ploughed back into the project knowledge areas for future projects.

There were a number of limitations to this research. The main limitation was that only the CSFs influencing two of the four success measures could be determined. In future research, care should be taken when determining the measuring scale of a success measure. The findings are also limited to small- to medium-sized projects; and it is proposed that such a study should also be conducted on large projects at Grootegeluk, to determine whether the CSFs are similar, independent of project size. Due to similarities in the findings to those of Fortune and White [17], it is expected that other mining companies will have similar CSFs for their small- to medium-sized projects. Future research should investigate this, and whether parallels can be drawn with other industries executing small- to medium-sized projects in South Africa.

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