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Critical success factors for projects in the petroleum industry

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Abstract

The paper identifies the critical success factors for petroleum projects. Factors have been obtained from existing literature and tested in the petroleum industry. The paper identifies 58 success factors that have been categorised into 11 groups. These factors were tested and grouped based on their individual relative importance index. The paper highlights the importance of project risk management and requirements management in achieving project success in the petroleum industry. The study also highlights the importance of the soft aspects of risk management in achieving successful implementation of project risk management and scope management in requirements management implementation.

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Keywords: Critical success factors; project success; petroleum projects; risk management; requirements management;

1. Introduction

The petroleum industry is one of the biggest individual sectors and the driving force behind many other sectors such as transportation. The estimated size of this sector according to MarketLine[1] is $3073.4 billion with a total volume

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of 46792.5 million barrels' equivalent; this is forecast to have a 4% increase by 2019.

The industry incorporates all the activities that have to do with exploration, extraction of crude and natural gas, refining, transportation and marketing of all petroleum products[2]. The industry is normally divided into three major sectors namely upstream, downstream and midstream[2].

According to Chan & Chan[3], project success is the end goal for every project. This has been a subject of debate by both researchers and industry[4]. The petroleum industry is a very lucrative and competitive environment with large multinational companies like British Petroleum (BP), Total, Chevron and Petronas. Such large corporations invest heavily in research and development and the results of this insight are strictly patented by the individual companies. This type of silent monopoly of the market makes it difficult for new market entrants such as developing nations that rely heavily on oil and gas. This makes it a necessity for them to undertake various joint venture agreements and contracts with such multinationals[5]. Undertaking such large projects in different parts of the world promotes the need of risk management as multinationals are exposed to working with people from different cultures, backgrounds and environments. This highlights the need for the identification of critical success factors for petroleum projects. The identification of these factors can lead the way for new entrants to join the market and deliver successful projects and for developing countries to increase their success rate in developing their own manpower to fully utilize the benefits without the need of the major players.

In the current petroleum industry, there is no formal definition of success nor the factors that can lead to success. However, there are generic factors that have been established for projects by different project management bodies such as the Association for Project Management and the Project Management Institute. Large multinational companies generally have their own way of doing things. Such procedures are generally only revealed when a disaster occurs and a public enquiry is undertaken (such as for the Deepwater Horizon accident[6,7]).

2. Background

2.1. Project management success and product success

It is important to understand and differentiate between "project success" and "project management success" as these two terms are different. According to de Wit[8], project management success is measured against a project's performance based on its initial estimates of cost, time and quality, while project success is measured against the overall objectives of a project.

Having introduced a project hierarchy framework, Baccarini[9] provides a clear distinction between project management success and product success, explaining that project management success focuses upon project success with regards to the accomplishment of the iron triangle, while product success deals with a project's final deliverable. The application of this concept implies that the project lifecycle encompasses both the processes and the product of a project. The two components are linked by smaller components known as inputs, outputs, purposes and goals.

The model is similar to that of Lim and Mohammad[10], which depicts the complete project life cycle and in each life cycle stage there are combinations of factors that contribute to the success of the project. The above frameworks are based on the stages of the project life cycle. As factors that will influence the outcome of a project depend on the stage the project is in, the separation of a project into stages is very important. A successful project is one that achieves both project management success and product success[9], but both scenarios are sometimes difficult to achieve[11]. This is something that is achievable if all parties are fully involved in a project. However, a project can be a product success without being a project management success if its objectives, which are based on the iron triangle, are not achieved.

2.2. Success criteria and success factors

Another set of project management concepts that need to be differentiated are "success criteria" and "success factors". Cooke-Davies[12] clearly defines success criteria as the measures by which the success or failure of a project will be judged, while success factors are inputs in a project that need to be managed as they strongly influence the success of a project. This view is also shared by researchers Lim and Mohammad[10] as they define the success criteria as the set of principles by which project success is or can be judged, while success factors are defined as the set of factors that influence the outcome of a project.

Having clear definitions of success criteria and success factors is very important because it is very easy to confuse the terms. In most cases, specific contributing factors could also be used as a measure to judge the other set of factors; this is discussed by researchers such as Dyrhaug[13], who emphasizes that project characteristics could influence the impact of a project's success factors. Other researchers[11,14] bring the notion that project success criteria should be clearly defined before a project starts after considering inputs from key project stakeholders

2.3. Project success

Research on project success has historically focused on the successful achievement of cost, quality and time objectives. More recent studies have suggested that newer sets of measures are required to measure project success[11,15]. A project is generally considered successful if its initial specifications are achieved and key stakeholders are satisfied with the outcomes of the project. Muller[16] suggests that projects differ in size, uniqueness and complexity, hence the criteria to measure success would vary between projects and from industry to industry; this in turn raises the question of whether a unique set of success criteria can be identified for all industries[17].

2.4. Critical success factors

The achievement of critical success factors (CSFs) provides implementers with a better understanding of how to improve the project outcomes. New entrants and smaller companies can use these factors to improve their project performance by utilizing their scarce resources in areas that would yield the highest returns[18].

CSFs can be defined as "those key areas of activity in which favorable results are absolutely necessary for a manager to reach his/her goals"[19]. Authors such as Futrell et al.[20] agree with this definition as they define CSFs as those factors in a project that can lead to positive outcomes of all project stakeholder expectations and requirements. Boynton & Zmud[21] state that the achievement of CSFs in projects ensures having a positive outcome.

CSFs have been used for decades as a means to achieve project success; they have also been implemented in a variety of sectors such as information technology[22] and construction[23], as well as for generic projects[24,25]. A review of the existing literature[26] identified the critical success factors and their corresponding categories. Table 1 shows the CSFs identified and tested in this study.

Table 1: CSFs identified in literature.

Category	Critical Success Factors	Sources
External Challenge	Economic environment, social environment, political environment, physical environment and regulatory/legal environment.	27,28,29
Client knowledge and experience	Nature of finance, experience, organization size, emphasis on cots quality and time, ability to brief, decision making, roles and contribution, expectations and commitment, involvement and influence.	27,28,30.
Top management support	Support given to project head, support to critical activities, understanding of project difficulty and stakeholder influence.	22,31,32.
Institutional factors	Standards and permits.	27.
Project characteristics	Project type, size, nature, complexity, design, resources allocation time and level of technology.	28,33.
Project manager competence	Experience, coordinating and motivating skills, leading skills, communication and feedback, management skills, conflict resolution skills and organizing skills.	34,35,36.
Project organization	Planning and control effort, team structure and integration, safety and quality program, schedule and work definition, budgeting and control of subcontractors.	23,27,32.
Contractual aspects	Contract type, tendering (procedures or steps for the selection of that service) and procurement (company selection to provide services) process.	28,29,33,37.

Project team competence	Team experience, technical skills, planning and organizing skills, commitment and involvement, teams' adaptability to changing requirements, working relationships, educational level, training availability and decision making effectiveness.	22,27,31,32.
Project Risk Management	The factors under project risk management are sub divided into two which are firstly hard aspects with initiation, identification, assessment, response planning, response implementation and secondly, soft aspects of risk, which are risk communication and attitude, monitoring and review	22,38,39.
Requirements Management	Elicitation technique, identification, analysis and negotiation, modelling, validation and scope management	39,40.

3. Methods

There has been little academic research on project management in the petroleum industry. The first stage of the research was therefore to examine CSFs from other industries to anticipate which of these might be applicable to the petroleum sector. Existing projects such as the Deepwater Horizon[6] and Ixtoc 1[41] were carefully analysed before a standard set of factors were obtained. These factors where then grouped into 11 categories.

The second strategy implemented was to develop a questionnaire using the key categories identified, asking experts in those fields to provide their views. The use of the questionnaire allowed the authors the opportunity to be able to analyse and quantify the data, and to test their hypotheses. The data was analysed with SPSS (Statistical Package for Social Science) software, to perform various tests such as reliability and factor analysis.

3.1. Questionnaire design

The questionnaire comprised of 37 questions, which were grouped into 5 sections. The first section collected general background information of the respondents, including aspects of experience and qualification. The second sections asked the respondents to rank the 11 CSFs based on a 10-point scale.

The third and fourth sections asked the respondents to weigh aspects of project risk management and requirements management respectively, also using a 10-point scale. The final section was optional, and asked respondents to provide their contact information, with the aim of getting possible candidates for future research.

Before the survey was released, a small pilot test was conducted with potential participants to get feedback on the questionnaire design. The recommendations they made were considered and adopted into the final survey.

3.2. Study sample

The survey was distributed to project managers and participants online via email and business-oriented social networking sites such as LinkedIn. The participants are geographically located in different parts of the world and have work experience in a variety of companies such as British Petroleum (BP), Halliburton, Chevron, the Nigerian National Petrochemical Corporation (NNPC) and Gazprom. The total number of completed and valid responses obtained from this survey was 49.

Most of the respondents were current project managers with Master's degrees and have an average of more than 15 years of project experience (not all of which was in the role of project manager). They have participated in more than 15 projects each with an average value of 1 million US dollars, delivering a variety of projects such as hardware, operational and service projects; they are mostly geographically located in the United Kingdom, United States of America, Nigeria, Netherlands and Russia.

4. Data analysis and findings

4.1. Relative importance index

Relative Importance Index (RII) is implemented with the aim to provide better understanding of individual predictors and their role amongst a given set[27]. The use of RII to find out the most significant factors has been used in existing project management literature[28,29,30]. The formula for RII is shown and explained below:

$$RII = \frac{\Sigma X}{Y * Z} = (0 \leq RII \leq 1) \tag{1}$$

X is the weight given to a factor by a respondent, in the range of 1 to 10. Y is the highest score available (10 in this case) and Z is the total number of respondents that have answered the question. The results of the relative importance index for the CSFs are shown in Tables 2, 3 and 4.

Table 2: RII of critical success factors.

Category	RII	Rank
Project Manager Competence	0.890	1
Project Organization	0.873	2
Project Team Competence	0.853	3
Project Risk Management	0.840	4
Requirements Management	0.835	5
Top Management Support	0.816	6
Contractual Aspects	0.798	7
Project Characteristics	0.761	8
Institutional factors	0.743	9
Client Knowledge and Experience	0.735	10
External Challenge	0.729	11

Table 3: RII of project risk management aspects.

Project Risk Management	RII	Rank
Communication and culture	0.865	1
Monitoring and Review	0.842	2
Identification	0.831	3
Planning of Responses	0.821	4
Initiation	0.821	4
Assessment	0.815	6
Implementation of responses	0.806	7

Table 4: RII of requirements management aspects.

Requirements Management	RII	Rank
Scope Management	0.868	1
Identification	0.855	2
Analysis and Negotiation	0.840	3
Validation	0.8	4
Modelling	0.774	5

4.2. Reliability of scale

Reliability of scale aims to "calculate the stability of a scale from the internal consistency of an item by measuring the construct"[31]. Nunnally & Bernstein[32] suggest that to ensure high internal consistency and reliability, the value for Cronbach's alpha should be greater than 0.7[33] (see Table 5).

Table 5: Reliability of scale.

Constructs	No of Items	Cronbach's Alpha
Critical Success Factors	11	0.872
Project Risk Management	7	0.912
Requirements Management	5	0.906

4.3. Factor analysis

According to Tabachnick & Fidell[34], one of the methods to perform factor analysis on a given set of data is to implement the Bartlett's test of sphericity, where the individual factor loading of each question should be greater than 0.5. After the test was carried out the lowest factor loading for a question was 0.652 and the highest was 0.869. Field[35] would consider this to be extremely good.

4.4. Regression test

4.4.1. Assumption of linearity

Osborne & Waters[36] suggest that if you're measuring the relationship between dependent and independent variables, both variables should have a linear relationship between them and the residual values should be between the ranges of -3 to 3. The results of this test as shown in Table 6 suggest that the data is linear because the minimum and maximum values come within this range. This means that there is a low risk of the collected data having errors.

Table 6: Linearity assumption.

	Minimum	MaximuM	Mean	Std. Deviation	N
Predicted Value	6.0823	9.2533	8.0716	0.74058	49
Residual	**-1.34423**	**1.30422**	.000	0.62080	49
Std. Predicted Value	-2.686	1.596	.000	1.000	49
Std. Residual	-2.118	2.055	.000	0.978	49

4.4.2. Multicollinearity

Garson[37] suggest that to avoid multicollinearity, the variation inflation factor and tolerance should be less than 10 and greater than 0.1 respectively. This test is carried out to ensure not having any multicollinearity issues between the variables that are being tested. From the results obtained from this test as shown in Table 7, the issue of multicollinearity does not arise.

Table 7: Multicollinearity test.

Predictor Variables	Tolerance	VIF
Critical Success Factors	0.529	1.889
Project Risk Management	0.519	1.926
Requirements Management	0.419	2.035

4.4.3. Hypothesis test

According to Berge & Sellke[38], for a hypothesis to be accepted and the null hypothesis rejected, the t-value and p-value should be analysed. The threshold for the t-value should be >2.0 and p-value should be <0.05 respectively. The two hypotheses tested in this paper have been accepted as both conditions have been met. See Table 8.

Table 8: Hypothesis test.

Hypotheses	Beta	t-value	p-value (Sig)	Outcome
H1: Project Risk Management	0.448	3.369	0.002	**Accepted**
H2: Requirements Management	0.386	2.898	0.006	**Accepted**

5. Discussion

Firstly, this research links project risk management and requirements management to project success in the petroleum industry. After performing the hypothesis test on the data, the result as shown in Table 8 supports the relationship between the two categories and project success. This has led to the rejection of the null hypotheses.

Secondly, as the two hypotheses have been accepted it is noteworthy to rank them against other categories of factors that can affect project success. To implement this, the use of the relative importance index was implemented to see how the factors stand amongst each other and determine which factor has the highest influence on a project. From the results obtained in Section 4.1, one can see that the most important factor is the project manager competence. It is rather surprising to find project risk management and requirements management both in the top five. Previous research has highlighted the importance of effective risk allocation in petroleum projects but failed to emphasize its importance as a top CSF[42].

More research should be carried out on these factors to establish their scope of applicability. We would like to establish if they are important to all projects in the petroleum industry, and whether they apply in other sectors as well. We would also like to understand why they haven't been considered as critical success factors before.

Thirdly in the aspect of project risk management, the results in Section 4.1 highlight the importance of the soft side of risk management, which consists of communication & culture and monitoring & review as they are deemed to be more important than the hard aspects (coming in first and second place).

Fourthly, scope management is deemed to be the most important aspect of requirements management. This normally entails the ability to capture and control the exact requirements.

Finally, the results of this paper highlight areas of focus when implementing projects in the petroleum industry. It provides an opportunity for smaller participating companies in the industry to know where limited resources can be placed to maximise the chance of achieving a positive result at the end of a project.

6. Conclusion

CSFs that can lead to project success have been an area of discussion in project management literature for some time, and some research has provided evidence that CSFs are sector specific. This has led to various attempts to try to establish these factors for different sectors. The paper identified 11 categories with 58 factors in total that can affect projects in the petroleum industry. These categories are important in projects because they strongly influence project outcomes.

The factors have been ranked based on their relative importance index. The study highlights the importance of risk management and requirements management in petroleum projects, with both ranked as more important than some already established categories, such as external challenge (which was ranked least important). The outcome of this research supports the need for further research to enable better implementation of project risk management and requirements management.

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