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Mitigating the Impact of Scope Change on Project Cost Performance in the Global Oil and Gas Industry: Innovative Strategies and Sustainable Solutions from the Nigerian Experience

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Abstract: This study investigates the impact of scope change on project cost performance in Nigeria's oil and gas sector, focusing on a significant pipeline project. Initially budgeted at $588.2 million, the project costs rose to $775.3 million due to scope changes over an extended timeline. Using a case

study approach, correlation and regression analyses revealed a statistically significant relationship between scope changes and increased project costs. The discoveries accentuate the need for effective scope management and recommend innovative frameworks to mitigate cost overruns, contributing to sustainable practices in the global oil and gas industry. The research offers valuable insights for project managers and policymakers aiming to optimize project execution and economic efficiency.

Keyword: Scope change, pipeline construction, correlation analysis, regression analysis, scope management, project cost performance, cost overruns, oil and gas industry

Introduction

The oil and gas industry is critical to Nigeria's economy, contributing significantly to its GDP

according to the National Bureau of Statistics (Nigeria). It accounts for up to 10% of the total between 2017 and 2020 [1] However,

pipeline construction projects in this sector often face challenges due to scope changes, leading to cost overruns and extended timelines. Stakeholders are concerned about the impact of scope creep, making it essential to develop strategies that mitigate these effects.

This study examines how scope changes affect project cost performance in Nigeria's oil and gas industry. Using an exploratory case study approach, data were collected from a significant public project—a 48" x 129.83km gas pipeline project in Nigeria. Originally budgeted at $588.2 million, the project experienced a substantial cost increase to $775.3 million over seven years beyond its initial two-year duration.

By applying correlation and regression analysis, the research demonstrates that scope changes have a statistically significant impact on project costs. This highlights the need for better scope management models to improve project execution and cost efficiency. As scope changes are inevitable, the development of robust models for managing these variables is vital for enhancing performance [2].

This paper contributes to ongoing discussions on scope management and cost control, offering innovative approaches that can be applied to future projects in both Nigeria and internationally. It aims to serve as a valuable resource for project managers, policymakers, and other stakeholders in the oil and gas sector, driving sustainable development through improved cost management strategies.

Literature Review

Relevant literatures are reviewed on scope change and its effect on project costs, with focus on key studies and concepts. [3] defines a project's scope as encompassing all work and expectations, forming the project's boundary. [4] describes scope change as adjustments to initial scope baselines, which can lead to delays, increased labor, and higher material costs [5]. The causes of scope changes include

regulatory actions, design modifications, field condition shifts, and unforeseen inflation [6]. Scope changes often result in cost overruns and schedule delays, with scholars like [7] emphasizing that understanding these impacts is critical for managing project baselines. [8] further note that many projects exceed budgets and schedules due to internal and external changes. Studies consistently find that scope changes can increase project costs by 5-10% in construction projects [9].

Empirical Review

[10] explored the global impact of scope change on project cost using PERT scheduling and correlation analysis, revealing that scope changes significantly affect planned budgets and final project costs. Similarly, [11] examined scope readiness and performance in Namibia's mining industry, finding that well-defined project scope improves schedule performance. [12] studied the effect of scope change on project success in Sudan, demonstrating increased project costs, duration, and quality. [13] focused on scope management practices in Nigeria's telecommunications industry, linking factors like customer satisfaction and resource allocation to project success but not directly addressing cost performance. While these studies converge on the impact of scope change, they differ in context and methodology, underscoring a need for further research on the relationship between scope change and contract costs, particularly in Nigeria's oil and gas sector. This study addresses these gaps using regression analysis.

Conceptual Review

Scope change can manifest in various forms, such as structural redesign, work rescheduling, recapitalization, equipment upgrades, and skills development. Structural redesigns may arise from environmental concerns, such as planning against climate risks like flooding, which leads to increased project costs. Similarly, work rescheduling due to political, legal, or social changes such as new policies or public holidays can impact project timelines and costs. In some cases, scope changes demand additional capital, equipment upgrades, or enhanced workforce skills, further driving costs. However, when managed well, scope changes can also offer economic and social benefits, creating jobs and investment opportunities. A predictive model to assess scope change impacts on project costs is crucial for achieving cost efficiency.

Theoretical Review and hypotheses development

The change theory of improvement science, introduced by Walter Shewhart in the 1920s and 1930s, serves as the theoretical foundation for this study [14]. Improvement science emphasizes rigorous inquiry, leveraging data analysis and measurements within Networked Improvement Groups to apply research-backed practices in localized contexts [15]. By focusing on evidence-based changes, this approach aims to elevate performance standards while minimizing failure risks. Given that scope change is an inherent part of project implementation, stakeholders must develop models to manage its impact on cost and other performance dimensions (Millhollan, 2008). Consequently, the study proposes two hypotheses:

- H0: No significant relationship exists between scope change and project cost.
- H1: A significant relationship exists between scope change and project cost.

Research Methodology

A case study approach was used for this research. The approach was considered good for the research it allows an in-depth examination of one aspect of the problem (Bjorvatn & Wald, 2018). However, the findings will mainly apply to cases with similar characteristics. The study adopts a survey design, using a deductive approach with primary and secondary data. Primary data was collected via structured questionnaires, measured on a 5-point Likert scale (Strongly Agree, Agree, Neutral, Disagree to Strongly Disagree), while secondary data was sourced from project reports. A purposive sampling technique was used, targeting 15 expert managers/consultants from key departments. All research variables had Cronbach's Alpha (α) values above 0.70. As a rule of thumb, acceptable alpha coefficient was put at 0.70 minimum [14] Hence, it implied the questionnaire used is reliable.

The research examined the communalities for each variable and all the factors extracted were above 0.4 coefficient, consequently, confirming the instrument's construct validity [10], Descriptive analysis was used to assess distribution rationality, and regression analysis was applied to test the hypothesis.

Data Analyses

The study employed SPSS and Excel for descriptive and regression analysis to quantify the correlation between scope change and project cost.

Descriptive Analysis

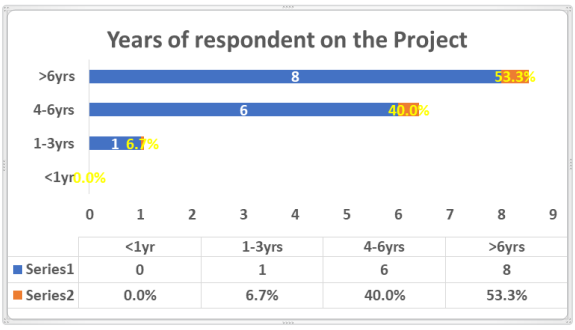
The descriptive analysis results of demographical data are shown in Table 1 and Figure 1 below.

Respondents Demography Respondents' Years on the Project

The respondents' experience on the empirical study project revealed that 53.3% (8 respondents) had less than 6 years on the project and were comparatively new too, 40% (6 respondents) had 4-6 years of experience, and 6.7% (1 respondent) had between 1-3years. This distribution is illustrated in Figure 1.

Figure 1

Years of Respondents on the Project



Also, the data reveals that all respondents were experienced and qualified to supply reliable information such that none of the participants had less than a year of experience on the project. One respondent (6.7%) had over a year of experience, while 40% of the respondents had 4-6 years, and 53.3% had more than 6 years.

Regression Analysis

The study prototype was got from the linear regression equation:

$Y = \beta_0 + \beta_1 X$

Where, Y (project cost) is the rough calculation of the dependent variable value.

β_0 is the average (constant) value of Y when X is zero.

β_1 is the average change in Y (project cost) relative to a unit increase in X (scope change).

X is the value of the dependent variable (project cost).

A univariate analysis was performed to examine the effect of scope change on total cost of project. The null and the alternative hypotheses are stated as follows:

H0: $\beta_1 = 0$

H0: $\beta_1 \neq 0$

Using the SPSS for the analysis of the linear regression, we obtained the measurement of the research model as follows:

Estimate of the standard deviation (model summary)

Table 1

MODEL SUMMARY

R	R-Squared	Adjusted R-Squared	Std. Error of the Estimate
.984	.968	.964	14663499.471

In the above table, the coefficient of determination R^2 indicates that the percentage of the total variance explained by the independent variable (scope change) is 96.8%.

Table 2

Regression Coefficients for project cost and scope change

	Unstandardized Coefficient		Standardized Coefficient		
Model	B	Std Error	Beta	t	Sig.
Scope change	9664911.653	659742.031	.984	14.650	.000
constant	575618241.489	9304208.074		61.866	.000

Dependent variable: project cost

Based on the unstandardized coefficients in table 2 above, we calculate the regression equation as follows:

$Y = \beta_0 + \beta_1 X$

$Y = 575618241.489 + 9664911.653X$

where X = scope change

Table 3

ANOVA - Computation by SPSS

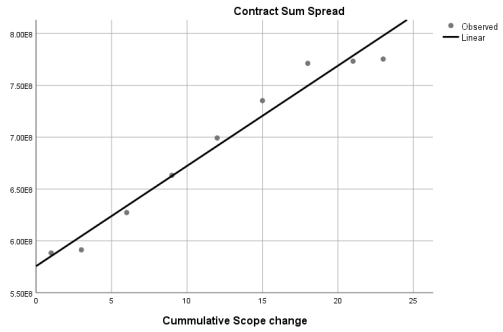
Model	*df*	Sum of Square	Mean Square	F	Sig. F
Regression	1	4614479552 2573472.00	461447955 22573472.00	214.609	.000
Residual	7	150512751707 6558.50	215018216 725222.66		
Total	8	4764992303 9650032.00			

The analysis of variance for linear regression could be made from the results in the above ANOVA table since most section of the total variance is derived from the regression equation.

The following figure present the line of best fit relating the relationship between project cost and Scope Change in graphical form.

Figure 2

Line of best fit-Contract Sum (project cost) versus Scope Change.



The coefficients for each variable assist the researcher to evaluate the importance of the independent variable. In this research the unstandardized coefficients and standardized coefficients are stated for the regression equation (see table 2). However, the focus is on the unstandardized coefficients.

Discussion of Findings

Table 2 shows a strong linear relationship between scope change and project cost, with a Pearson correlation (R) of 0.984 and R^2 of 0.968, indicating that 96.8% of the variance in project cost is explained by scope change. The Beta coefficient of 9664911.653 suggests that each scope increase raises the cost by $9,664,911.65, while the cost remains $575,618,241.49 when scope change is zero. The regression model is:

Project cost (Y) = 575618241.489 + 9664911.653 (scope change).

The regression model indicates that each unit increase in scope change is associated with a $9,664,911.65 increase in project cost.

Table 3 confirms the significant relationship between scope change and project cost, with a p-value of 0.000, which was less the significant level 0.05. Thus, rejecting the null hypothesis that scope change has no significant effect on project cost. This result corroborates the previous research by Tariq et al. (2020).

Conclusion

This study gathers that scope change has a positive and statistically significant impact on project execution costs, highlighting the importance of effective scope change management to improve cost

performance. Specifically, the research discovered that scope change affected the cost performance of the Obiafu/Obrikom-Oben (083) gas pipeline project in Nigeria. Establishing a model linking scope change to project execution costs can help project management optimize scope activities and minimize cost overruns. Proper scope control would prevent fund loss, allowing resources to be used for business growth or investment. Hence, developing a robust template for scope control can contribute to economic growth in Nigeria and in any organization that adopts the models and strategies.

Recommendation for Further Studies

This research work like other related studies has its strength and limitations. Hence, the study hereby offers the following suggests for future research so as to improve its core values:

1. Conducting research with larger samples can improve the generalizability of findings.
2. Explore how emerging technologies such as AI and blockchain can enhance scope change management.
3. Conduct research from the contractor's perspective to assess cost overruns and profit margins.
4. Study the impact of scope changes on project quality, safety, and labor productivity.

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