

-RESEARCH ARTICLE-

OPTIMISING BIG DATA ANALYTICS AND KNOWLEDGE MANAGEMENT FOR SUSTAINABLE QUALITY MANAGEMENT IN UPSTREAM OIL & GAS PROJECTS: A QUANTITATIVE STUDY

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—Abstract—

This research explores how big data analytics and knowledge management contribute to the development of quality management practices in the upstream oil and gas service

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industry, with the aim of strengthening operational efficiency and achieving sustainable project outcomes. A quantitative methodological approach is employed, concentrating on the relationship between knowledge management and quality management practices, as well as project sustainability performance, in addition to assessing the effect of big data analytic capability on quality management systems and project sustainability performance. The empirical data were obtained through purposive sampling of 183 senior professionals and managers working within project management offices. Data analysis was conducted using partial least squares structural equation modelling (PLS-SEM). The findings demonstrate that knowledge management has a strong and positive influence on both quality management practices and project sustainability performance. Conversely, big data analytic capability exhibits a relatively weaker effect, which is largely attributable to the early phase of digital technology adoption within the industry. Moreover, quality management practices are found to be a key determinant in enhancing overall project sustainability.

Keywords: Big Data Analytic, Knowledge Management, Quality Management, Project Sustainability

INTRODUCTION

The oil and gas industry represents a substantial and economically significant sector, yet it is characterised by a high level of exposure to political, geological, economic, supply chain, and environmental risks. Operating under such uncertainty requires oil and gas firms to conduct rigorous and systematic risk assessments to ensure organisational continuity and long-term viability (Özgür & Wirl, 2020). In response, companies have increasingly developed comprehensive risk profiles that span operational activities, resource deployment, and asset classifications, while also integrating project-level considerations into broader corporate strategy assessments. A considerable proportion of exploration and production activities rely on outsourced equipment, specialised personnel, and technical services covering drilling, production, facility construction, maintenance, and repair. Within this structure, oilfield service companies are engaged by oil and gas operators to support upstream asset operations. As integrated service models and project-based contracting become more prevalent, a growing share of operational and project-related risks is transferred from operators to oilfield service providers (Wanasinghe et al., 2020).

Oilfield service organisations are responsible for managing a wide range of functions, including operational execution, workforce management, equipment provision, logistics coordination, and safety assurance (Hadd, 2019; Report, 2020). The sharp decline in oil prices in 2014 had a pronounced adverse impact on the oil and gas sector, intensifying financial and operational pressures across the industry (Report, 2020). Nevertheless, overall production levels have remained relatively stable, supported by persistent global demand. This context has heightened the emphasis on efficiency within oilfield service operations, as operators seek to optimise output from both

existing and newly developed wells. As a result, efficiency-driven strategies have become a key driver of growth within the oilfield services market (Eberhart, 2021).

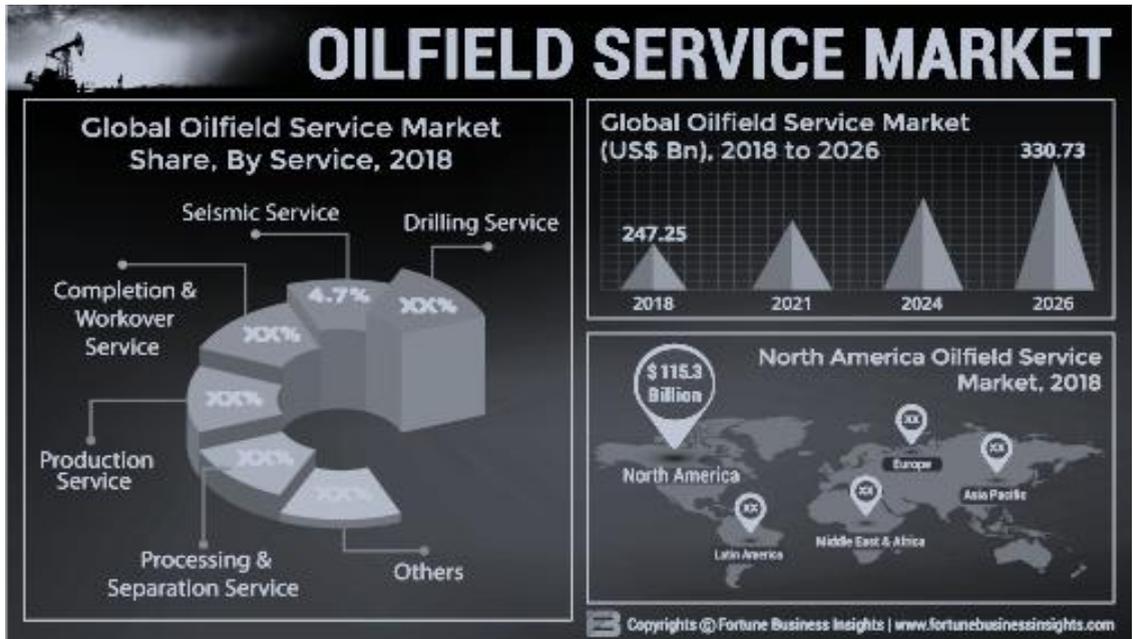


Figure 1: Oilfield Service Market
Source: Fortunes Business Insight Report (2020)

To remain competitive in the highly volatile oilfield service market, firms are increasingly required to adopt rapid and informed decision-making processes supported by big data analytics and knowledge management capabilities, thereby strengthening their strategic positioning (Choi et al., 2022). Although concerns regarding a potential global economic slowdown persist, West Texas Intermediate crude futures recently exceeded 95 dollars per barrel, driven by supply limitations and record export levels from the United States (WTI). Within this environment, upstream oil and oilfield service sectors continue to operate under significant uncertainty, while simultaneously placing greater emphasis on internal integration and coordination to support long-term project sustainability (Hutomo et al., 2018). Persistent challenges related to data standardisation and system integration remain evident across the industry, constraining the effective use of digital resources (Slaughter et al., 2021). Nevertheless, oilfield service firms are actively pursuing innovation through advanced technologies such as big data analytics, which contribute to shorter drilling cycles and improved risk identification and control mechanisms (Sang et al., 2021). Building on existing research in predictive analytics and knowledge management, this study examines their combined influence on project management and quality management practices within the upstream oilfield service sector, with the objective of clarifying their roles in enhancing operational efficiency, mitigating risk, and supporting project sustainability.

LITERATURE REVIEW

Big Data Capability

Big Data represents a pivotal concept within the oil and gas sector, encompassing the substantial volume, diversity, and velocity of data produced through operational activities and decision-making processes (Skinner, 2018). Despite its recognised potential, greater adoption and implementation efforts are required to fully harness Big Data for enhancing organisational performance (Pandey & Branson, 2020). The relationship between Big Data and Knowledge Management (KM) is well established, with research indicating its capacity to generate substantial impact in this domain. Evidence suggests that oil and gas enterprises employing Big Data are twice as likely to attain superior financial evaluations, five times more likely to accelerate decision-making, and three times more likely to execute decisions within designated timelines. Key dimensions and metrics of extensive information capabilities encompass technological factors, including technical proficiency, targeted analytical approaches, and structured planning, alongside managerial elements such as decision-making processes. Collectively, these insights emphasise the critical need for developing and strengthening Big Data capabilities to enhance competitiveness and operational success within the oil and gas industry (Akter et al., 2016).

Knowledge Management

KM constitutes a structured organisational strategy designed to integrate human resources, technology, processes, and organisational frameworks to maximise value through both knowledge reuse and innovation (Natalicchio et al., 2017). It encompasses the creation, dissemination, and application of knowledge derived from prior experiences and actions, thereby supporting continuous organisational learning. By leveraging existing information technologies, organisations can strengthen their core competencies and foster sustained value generation through cultivating a communicative culture, providing learning opportunities, and promoting knowledge sharing (Azeem et al., 2021). Fundamental dimensions and metrics of KM include knowledge acquisition and generation, which cover the development of financial reporting systems, engagement in international collaborations, responsiveness to market dynamics, and utilisation of survey-derived insights (Pan, 2021). Knowledge-sharing processes involve technology-enabled dissemination, on-the-job knowledge transfer, active employee participation in decision-making through experiential input, and the maintenance of organisational memory for efficient retrieval of stored information (Deng et al., 2023). Furthermore, collaborative, exploitative, and explorative learning incorporates the application of knowledge sourced from diverse stakeholders to refine operational processes, formulate innovative strategies, engage in joint planning and design, and facilitate problem-solving initiatives (Martinez Sanz & Ortiz-Marcos, 2020).

Quality Management

Total Quality Management (TQM) represents a conventional managerial framework that employs the Input-Process-Output (IPO) model to delineate interactions within organisational systems (Chen et al., 2019). TQM practices contribute to an organisation's sustainable competitive advantage by enhancing managerial capabilities and emphasising the continuous refinement of resources. Contemporary investigations into TQM dimensions and their influence on organisational performance often produce divergent outcomes, largely attributable to the framework's inherent static characteristics (Oakland, 2014). To address these limitations, dynamic analyses grounded in the Resource-Based Theory (RBT) are recommended, incorporating both internal and external determinants. Core dimensions of quality management include compliance with established quality management system standards, such as ISO 9001 and API Q2, effective deployment aimed at improving customer service efficiency and expanding market share, and soft TQM elements, which encompass well-defined strategic objectives and expertise in statistical process control (Brito et al., 2020; Khalili et al., 2019).

Project Sustainability

In recent years, social and environmental considerations have become fundamental components of project sustainability, highlighting the need for their integration into organisational structures and business operations. Sustainability should not be treated as an isolated initiative but rather embedded within the organisation's strategic objectives to achieve superior performance (Chorley, 2021; Muralikrishna & Manickam, 2017). Beyond conventional financial indicators, sustainability provides a framework for organisations to operate profitably while maintaining responsible practices. Key dimensions and indicators of project sustainability performance encompass traditional project success measures, including cost, time, and quality, as well as supplementary factors such as cost efficiency, operational effectiveness, and market share enhancement (Caiado et al., 2019; Leong et al., 2014; Wu et al., 2019).

Research Framework

The oil and gas (O&G) service sector faces increasing pressure to adopt digital transformation in order to sustain competitiveness amid evolving industry challenges. Digital technologies provide opportunities to enhance productivity, safety, and cost efficiency, offering resilience against market fluctuations. Nonetheless, the complexity of the digital environment presents significant implementation challenges. The proposed research framework centres on the interplay between Big Data Capability, KM, Quality Management (QM), and Project Sustainability (PSP). Big Data Capability supports the management and analysis of extensive datasets, which directly complement KM processes. QM, with an emphasis on TQM, strengthens competitive advantage through continuous operational improvement. PSP involves the attainment of project objectives while integrating strategic considerations such as efficiency and social and environmental responsibility.

Within the context of industry restructuring, upstream operators seek to sustain project performance by leveraging digitalisation and organisational learning. Inadequate service quality can adversely affect project outcomes, financial performance, and environmental standards. Internal assessments indicate a need for enhanced expertise in project management and a stronger focus on process adherence within quality management. From a resource perspective, challenges include effectively applying knowledge and managing substantial data, suggesting the necessity for strategies to compensate for resource limitations. This study therefore focuses on the influence of environmental conditions and internal strategies, particularly the enhancement of Big Data and KM capabilities, alongside process linkages derived from project and quality management practices, within the upstream O&G service sector. This rationale underpins the development of the research framework presented in [Figure 2](#).



Figure 2: Research Framework

RESEARCH METHODS

This study utilises quantitative research methods, as it is grounded in positivist principles and relies on numerical data subjected to statistical analysis to derive conclusions. Quantitative approaches enable precise investigation of factual relationships between variables, making them particularly suitable for examining the effects of Big Data Analytics (BDA) and KM on QM and Project Sustainability Performance (PSP) ([Bougie & Sekaran, 2020](#)). The research population comprises employees within the Upstream Oilfield Service industry, specifically leaders or managers operating within Project Management Offices (PMOs). A purposive sampling technique was employed to identify 183 respondents who satisfied the inclusion criteria. Data were collected through structured questionnaires, utilising a seven-point Likert scale. Quantitative methods were selected for their capacity to rigorously test hypotheses and generate dependable findings using validated instruments. The operational variables were established through assessments of content validity, construct validity, and reliability analysis using Cronbach's Alpha, thereby ensuring both the accuracy and consistency of the data ([Sürücü & Maslakci, 2020](#)). Consequently, the application of quantitative methods enhances the validity and reliability of the study within a structural equation modelling framework (SEM-PLS), producing precise and robust results. The operational variables serving as parameters in this investigation are defined as follows in [Table 1](#).

Table 1: Variable Operations

Variable	Dimension	Indicator	Item	Questionnaire Statement
Big Data Capability	Big Data Analytic Technological Capability	Technical Knowledge/ Expertise/ Competency	BDAC1	Our organization possesses technical knowledge/expertise in big data analytic.
		Centralized Analytic	BDAC2	Our organization's big data analytics is performed on a centralized data server.
		Multi-Platform	BDAC3	Our organization's big data analytics can be run on multiple platforms (Eg: Azure, Hadoop, Satori, Power BI, Tableau).
		Met Various Analysis Needs	BDAC4	Our organization's big data analytic outputs can meet various project analysis needs (Eg: planning needs, risk analysis, tracking, and monitoring of the project).
		Customizable Application	BDAC5	Our big data analytics applications are easily customized.
	Big Data Analytic Management Capability	Systematic Planning	BDAC6	Data analytic outputs are used in the systematic planning of projects.
		Information Sharing	BDAC7	Our organization shares information from data analytic results.
		Decision Making	BDAC8	Our organization's data analytics outputs are utilized to make strategic decisions for the project.
		Proper Data Management	BDAC9	Data from various projects are properly managed.
		Awareness	BDAC10	*) Not everyone is aware of the benefit of big data analytics.
		Continuous Monitoring	BDAC11	Big data analytics helps continuous monitoring of our projects.
Knowledge Management	Knowledge Acquisition/ Generation	Develop a Good Financial Reporting System	KM1	Our organization has developed a well-developed financial reporting system.
		International Cooperation for Training Development will be Implemented	KM2	International collaboration to enhance learning between project teams from different countries is evident.
		Sensitive Information about Market Changes	KM3	Market information is used to obtain confidential information about competitors.
		Get Information from Market Research	KM4	*) We do not take advantage of information from market research.
	Knowledge Sharing	Share Knowledge using Technology	KM5	Our company's project team shares knowledge using the latest and most up-to-date technologies.
		Knowledge is Disseminated in the Workplace	KM6	Best practices from past and current projects are shared regularly in the workplace.

Variable	Dimension	Indicator	Item	Questionnaire Statement
		Involve Employees in Sharing their Decision-Making Expertise	KM7	Employee input is invaluable in management decision making.
		Organizational Memory is the Storage and Quick and Easy Access to Information Stored in an Organization's History	KM8	The lessons learned are easy to remember and record.
	Knowledge Utilization/ Collaborative, Exploitative & Explorative Learning	Use Knowledge from Customers, Suppliers, and Employees to Improve Company Processes	KM9	Internal and external input is used to improve existing processes.
		Develop New Processes	KM10	Internal and external input is used to develop new processes.
		Joint Planning and Design	KM11	There is evidence of joint planning between the project team, client and suppliers during the design phase of the project.
		Solve the Problem	KM12	Information, knowledge, and learning help solve project problems and issues.
Quality Management	Quality Management System Standard	Implementation and Validation	QM1	Our organization has a Quality Management System certificate (ISO 9001:2015, API Q2 or other similar Quality Management System).
		Maintenance Process	QM2	Organizations make efforts to maintain their certification.
	QMS Implementation	Improve Customer Service Effectiveness and Organizational Culture	QM3	Implementing a quality management system supports an effective project organizational culture.
		Use in Offers to Increase Market Participation	QM4	Obtaining ISO 9001 or API Q2 certification improves market position.
		Conduct Regular Internal Audits	QM5	Routine internal audits are carried out as part of normal procedures.
		Respond to Customer and Regulatory Requirements through Use	QM6	Customer and regulatory requirements drive QMS implementation.
		Use ISO9001 to Implement Additional Standards Such as ISO 14000, API Q2,	QM7	ISO 9001 QMS certification is the first step towards compliance with other standards such as ISO 45001.

Variable	Dimension	Indicator	Item	Questionnaire Statement
	Soft TQM Aspects	API Q1, etc.		
		Clear Strategy Goals, Communication	QM8	Quality policies and strategies are well understood in our organization.
		Knowledge of Strategic Objectives	QM9	Quality policies and strategies are understood in our organization.
		Detailed Design Tasks for QM Practice	QM10	Tasks are carefully planned to ensure QMS implementation.
		Static Process Control Concept	QM11	This project applies statistical process control for quality control.
Project Sustainability	Project Success	Accuracy of Cost Performance/Budget Estimates	PS1	Previous and current projects are at or below estimated costs.
		Timer Performance	PS2	Past and present projects are on schedule or completed ahead of schedule.
		Quality Performance	PS3	Past and present projects meet customer expectations.
		Cost Reduction/Cost Savings	PS4	Past and present projects have cost-saving activities.
		Operational Performance	PS5	Past and present projects achieved optimal operational performance.
		Share	PS6	Increasing market share depends on the success of the project.
	Project Sustainability	Sustainability - Prioritize Efficiency and Profitability	PS7	Past and present projects are profitable and effective.
		Sustainability-Stakeholder Satisfaction and Expectations	PS8	Past and current projects meet or exceed stakeholder expectations.
		Sustainability-Environment, Health and Safety	PS9	There have been no serious environmental, health or safety violations on any previous or current projects.
		Sustainability-Social Responsibility Humanitarian and Social Activities	PS10	Past and present projects contribute to the local community.

Sources: (Abbas, 2020; Chin et al., 2020; Demir et al., 2023; Dubey et al., 2019; Ferraris et al., 2019; Li et al., 2020; Mangla et al., 2021; Rialti et al., 2020; Sanguesa et al., 2021; Shabbir & Gardezi, 2020; Zhai et al., 2018).

The analysis of research data was conducted using PLS-SEM, which is particularly suited for testing complex structural models. The PLS-SEM framework employed in this study comprises assessments of convergent validity, average variance extracted (AVE), discriminant validity, reliability, and evaluation of the structural model. Measurement (outer) models were utilised to examine the validity and reliability of the relationships between indicators and their corresponding latent constructs. Additionally,

a nested model approach was implemented to determine the significance of relationships among the various components within the research design (Hair Jr et al., 2017; Sarstedt et al., 2019).

RESULTS AND DISCUSSION

The study was carried out with 183 participants who fulfilled the inclusion criteria and were employed within the upstream petroleum services sector. The demographic characteristics of the respondents are presented as follows. Figure 3 explained the outer model.

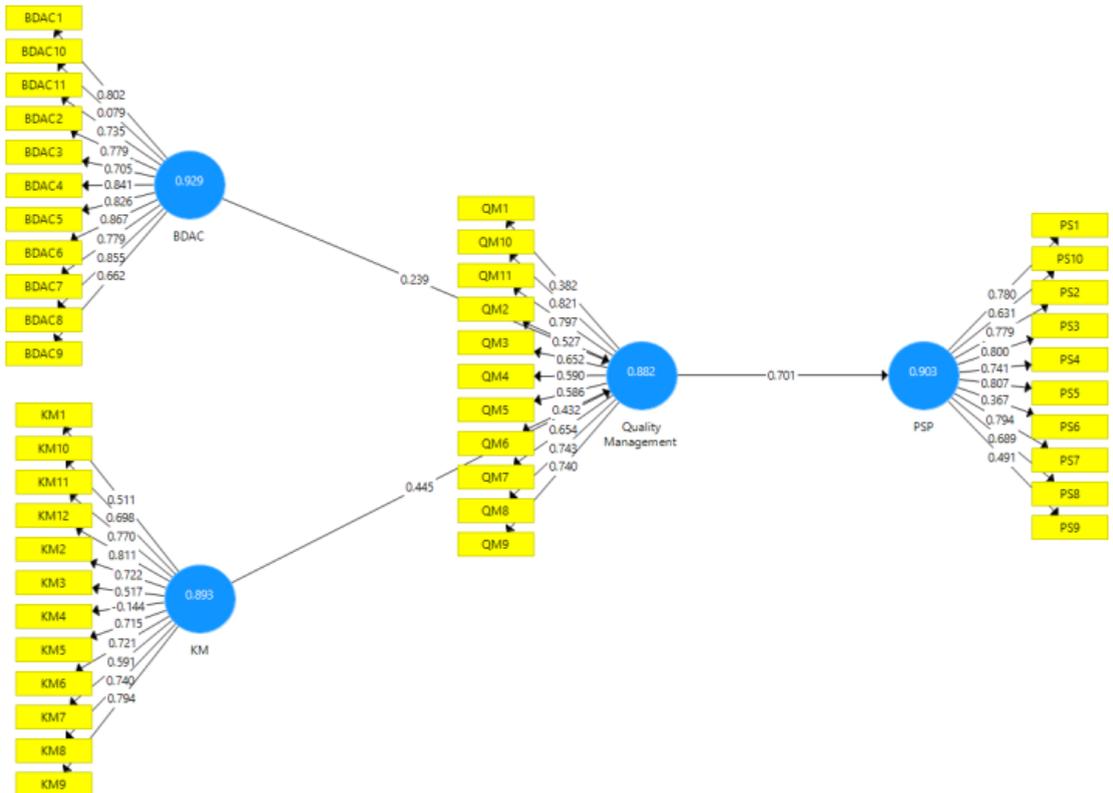


Figure 3: Outer Model

Country

The respondents' demographic distribution by country highlights the proportion of employees working in the Upstream Oilfield Service Industry within Indonesia compared to those based internationally. The corresponding results are illustrated in Figure 4. Analysis of respondents' demographics by country revealed that, of the 183 participants, a majority of 70.49% were employed within the International Upstream Oilfield Service Industry, while the remaining 29.51% were affiliated with the Indonesian Upstream Oilfield Service Industry.

International / Indonesia

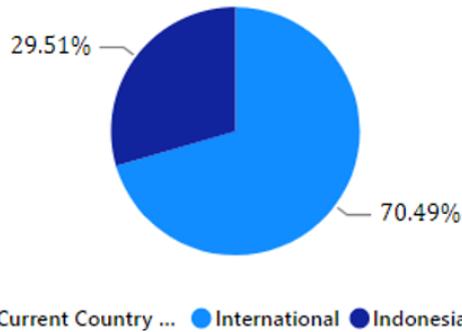


Figure 4: Respondent Demographics by Country

Region

The respondents' demographic distribution by region illustrates the proportion of employees working in the Upstream Oilfield Service Industry across various global regions, as presented in Figure 5. Among the 183 participants, the largest share, 40.98%, were employed in the Asia Pacific & Australia region. This was followed by 22.4% in the Middle East & Africa, 19.13% in Europe & Eurasia, 13.11% in North America & Canada, and 4.37% in Latin America.

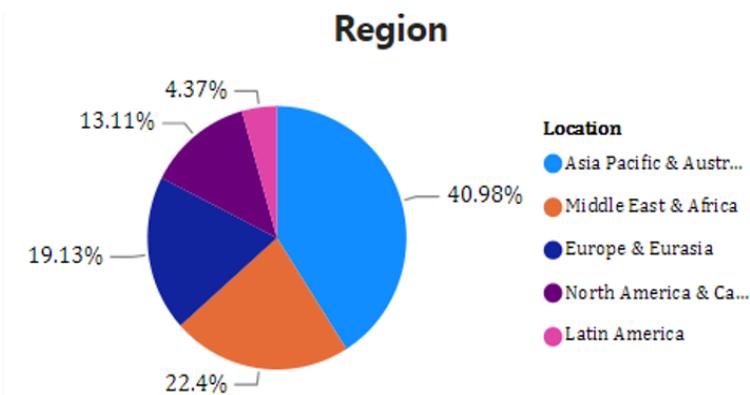


Figure 5: Respondent Demographics by Region

Organization Age

The respondents' demographic profile by organisational age reflects the distribution of employees within Upstream Oilfield Service Industry companies of varying establishment periods, as illustrated in Figure 6. Of the 183 participants, the majority, 60.11%, were employed in organisations with an age exceeding 40 years. The remaining respondents were distributed as follows: 19.13% in companies aged 10–20 years, 15.85% in organisations aged 20–40 years, and 4.92% in companies established for less than 10 years.

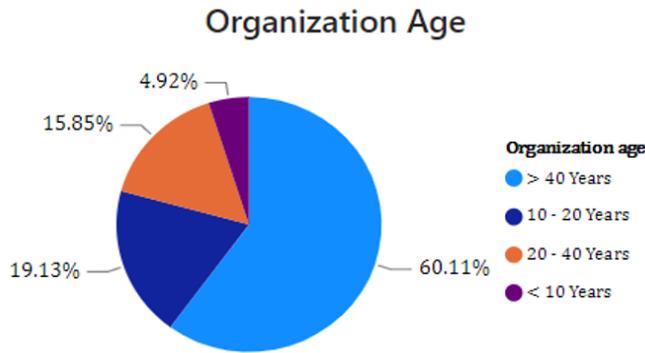


Figure 6: Respondent Demographics Based on Organizational Age

Term of Project Management Office

The respondents' demographic distribution regarding the presence of a Project Management Office (PMO) within their organisations is presented in Figure 7. Among the 183 participants, the largest proportion, 29.51%, reported that a PMO had been established for 10–15 years. This was followed by 28.42% indicating a PMO presence of 5–10 years, 26.23% reporting a PMO operational for more than 15 years, and 10.93% stating that their PMO had been recently established (less than 5 years). A minority of 4.92% of respondents indicated that their organisation did not have a dedicated PMO.

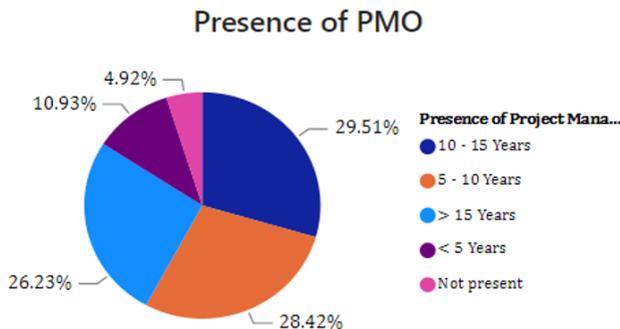


Figure 7: Respondent Demographics Based on the Term of Project Management Office

Division

The respondents' demographic profile by project management division illustrates the distribution of employees across various functional areas within the Upstream Oilfield Service Industry, as depicted in Figure 8. Analysis of the 183 participants indicates that the majority, 64.48%, were employed in well construction/drilling and completions. The remaining respondents were distributed across other divisions as follows: 12.02% in surface facilities, 6.56% in well intervention, 4.92% in geophysics/subsurface/seismic, 4.37% in EPC/construction, 3.83% in HSE/quality/integrity management, and 3.82% in regulatory functions.

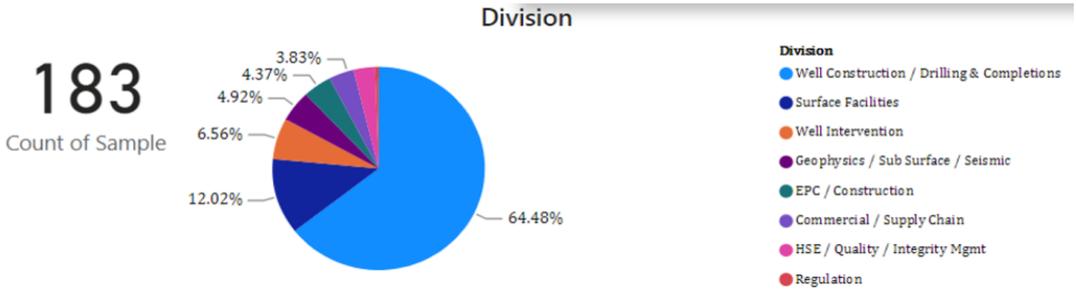


Figure 8: Respondent Demographics by Division in Project Management

Following the collection of respondents' demographic data, the research proceeded to data analysis using PLS-SEM. The first stage of this analytical process involved the following steps:

Outer Model Analysis

As illustrated in Table 2 and Figure 9, several indicators were excluded because their outer loading values fell below the established threshold of 0.708. Indicators with values exceeding 0.708 were deemed reliable for measuring the corresponding research constructs.

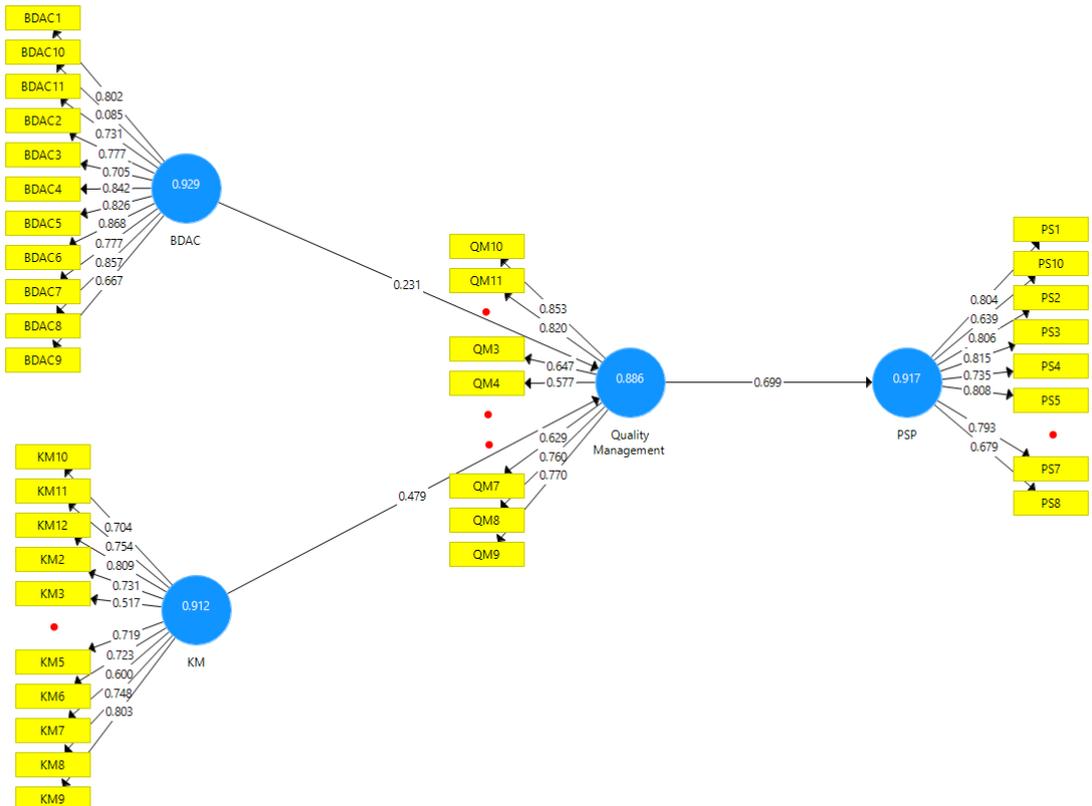


Figure 9: Outer Model

Table 2: Discriminant Validity

Variable	Indicator	Outer Loading	
Big Data Analytic Capability	BDAC1	0,802	
	BDAC2	0,777	
	BDAC3	0,705	
	BDAC4	0,842	
	BDAC5	0,826	
	BDAC6	0,868	
	BDAC7	0,777	
	BDAC8	0,857	
	BDAC9	0,667	
	BDAC11	0,731	
Knowledge Management	KM2	0,731	
	KM3	0,517	
	KM5	0,719	
	KM6	0,723	
	KM7	0,600	
	KM8	0,748	
	KM9	0,803	
	KM10	0,704	
	KM11	0,754	
	KM12	0,809	
	Quality Management	QM3	0,647
		QM4	0,577
QM7		0,629	
QM8		0,760	
QM9		0,770	
QM10		0,853	
Project Sustainability	PS1	0,804	
	PS2	0,806	
	PS3	0,815	
	PS4	0,735	
	PS5	0,808	
	PS7	0,793	
	PS8	0,679	
	PS10	0,639	

As presented in [Table 3](#), all research indicators exhibited an AVE value of 0.5, indicating that the construct validity for each variable was satisfactory and could be accepted.

Table 3: Average Variance Extracted (AVE)

Variable	AVE
BDAC	0,565
KM	0,512
QM	0,581
PS	0,531

As shown in [Table 4](#), the HTMT ratio for all variables was below the threshold of 0.9 (HTMT < 0.9), indicating that each construct demonstrates satisfactory discriminant validity.

Table 4: Heterotrait – Monotrait Ratio (HTMT)

Variable	BDAC	KM	PSP	QM
BDAC				
KM	0,820			
PS	0,552	0,714		
QM	0,645	0,715	0,770	

The reliability assessment, as presented in [Table 5](#), indicates that all research variables satisfied the criteria for both Composite Reliability and Cronbach’s Alpha. A variable was considered reliable if its Cronbach’s Alpha exceeded 0.7, and all variables met this requirement, confirming their consistency and dependability.

Table 5: Composite Reliability and Cronbach Alpha

Variable	Cronbach’a Alpha	Composite Reliability
BDAC	0,911	0,929
KM	0,892	0,912
PS	0,896	0,917
QM	0,851	0,886

Inner Model Analysis

As indicated in [Table 6](#), the R² value for the PSP variable is 0.489, signifying that BDA, KM, and QM collectively account for 48.9% of the variance in PSP. Similarly, the R² value for the QM variable is 0.447, indicating that 44.7% of the variance in QM can be explained by BDA and KM.

Table 6. R – Square

Variable	R Square	R Square Adjusted
Project Sustainability	0,489	0,486
Quality Management	0,447	0,441

[Table 7](#) presents the F² values, which indicate the impact of independent variables on dependent variables. According to established criteria, an F² value of 0.02–0.15 denotes a weak effect, 0.15–0.35 signifies a moderate effect, and values exceeding 0.35 indicate a strong effect of the latent variable predictor at the structural level ([Ghozali, 2018](#)). In this study, the results reveal that BDA on QM exerts a weak influence, with an F² value of 0.043. KM on QM demonstrates a moderate effect, with an F² value of 0.183. Finally, QM on PSP exhibits a strong influence, with an F² value of 0.956.

Table 7: F Square

Variable	Project Sustainability	Quality Management
Big Data Analytic Capability		0,043
Knowledge Management		0,183
Project Sustainability		
Quality Management	0,956	

The results from the hypothesis testing presented in Table 8 show the relationships between various factors and their impact on project sustainability performance through quality management. The first effect, Big Data Analytic Capability to Quality Management, has a T statistic of 0.231 and an R² of 0.447, indicating a moderate effect of Big Data Analytics on Quality Management. The second effect, Knowledge Management to Quality Management, has a T statistic of 0.479, although no R² value is provided. For Quality Management to Project Sustainability, the T statistic is 0.699, with an R² of 0.489, suggesting a stronger relationship and a moderate explanatory power between quality management and project sustainability. Furthermore, Big Data Analytic Capability to Project Sustainability Performance through Quality Management shows a lower T statistic of 0.161, indicating a weaker indirect effect, while Knowledge Management to Project Sustainability Performance through Quality Management has a T statistic of 0.335, also reflecting a moderate, indirect influence.

Table 8: Hypothesis Test Results

No	Effect	T Statistic	R2
1	Big Data Analytic Capability to Quality Management	0,231	0,447
2	Knowledge Management to Quality Management	0,479	
3	Quality Management to Project Sustainability	0,699	0,489
4	Big Data Analytic Capability to Project Sustainability Performance through Quality Management	0,161	
5	Knowledge Management to Project Sustainability Performance through Quality Management	0,335	

DISCUSSION

The oil and gas industry, a critical driver of economic activity, is exposed to a wide spectrum of risks, including political, geological, economic, supply chain, and environmental challenges. Organisations undertake comprehensive risk assessments to operate effectively under uncertainty, developing detailed profiles for operations, resources, and assets while evaluating long-term strategic directions. Awareness of human, financial, and environmental risks was particularly heightened following the Deepwater Horizon incident a decade ago, emphasising the necessity for robust risk management practices (Beattie, 2021; Wells et al., 2019). Based on the analysis conducted, the research yielded the following findings:

1. BDA exerts a significant influence on QM (t-value = 0.231 > 1.96), enhancing quality management practices. TQM, utilising the IPO framework, elucidates the interactions within the system, and access to high-quality information, combined with learning from prior experiences, supports effective management.
2. KM significantly affects QM (t-value = 0.479 > 1.96), facilitating the efficient utilisation of organisational knowledge. Tacit knowledge is transformed into explicit knowledge, aided by technological tools, thereby supporting processes such as new product development.
3. QM practices have a significant impact on PSP (t-value = 0.699 > 1.96), contributing to project success and strengthening competitive advantage in a challenging industrial environment.
4. BDA influences PSP indirectly through QM (t-value = 0.161 > 1.96), thereby enhancing project management practices and outcomes.
5. KM affects PSP via QM (t-value = 0.335 > 1.96), supporting project management processes and sustaining project performance.

These findings provide comprehensive insights into the interrelationships among BDA, KM, QM, and PSP within the oil and gas sector. Nevertheless, certain limitations of the study should be acknowledged to ensure nuanced interpretation of the results.

RESEARCH CONTRIBUTION

Practical Contribution

BDA plays a critical role in enhancing PSP within the upstream oil and gas sector by allowing organisations to optimise drilling operations, minimise environmental impacts, and strengthen safety performance.

Theoretical Contribution

The significance of BDA in the upstream oil and gas sector, together with its interactions with KM, QM, project management practices, PSP, and environmental factors, enables organisations to effectively achieve sustainable project outcomes.

CONCLUSION

Based on the findings of this study, the following conclusions can be drawn:

1. KM within the Upstream Oilfield Service Industry exerts a strong influence on both QM practices and PSP, underscoring the central role of organisational knowledge in supporting operational excellence and sustainable project outcomes.

2. BDA demonstrates a comparatively weaker effect on QM and PSP, which can be attributed to the fact that 85% of respondents indicated digital adoption remains at an early stage and has not yet been fully integrated into organisational processes.
3. QM practices exert a substantial impact on PSP, highlighting their critical importance in achieving project success and maintaining competitive advantage in the upstream sector.

Overall, these results emphasise the pivotal role of KM and QM in driving PSP within the Upstream Oilfield Service Industry. While KM facilitates the enhancement of quality practices and supports sustainable project performance, the early-stage implementation of digital technologies limits the full potential of BDA. The effectiveness of QM remains a key determinant of project success. However, study limitations, including the representativeness of the sample, should be considered when interpreting these conclusions to ensure comprehensive understanding.

SUGGESTIONS

Based on the research variables, it is evident that upstream oil and gas organisations must consider each variable carefully when developing operational risk management plans. This involves employing both qualitative and quantitative analytical methods and ensuring the availability of skilled resources to innovate, enhance, and execute organisational operations effectively, thereby supporting the smooth functioning of upstream oil and gas activities.

RESEARCH LIMITATIONS

This study encountered several limitations that may have influenced the research outcomes, including:

1. The limited timeframe for conducting the study, despite the need to manage a relatively large sample.
2. The research was confined to a single focus area, specifically the Upstream Oilfield Service Industry, serving as the sole research site.
3. The study considered only a subset of factors affecting PSP, concentrating on BDA, KM, and QM, while other potentially influential variables were not examined.

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