ASSESSING KEY FACTORS IMPACTING THE PERFORMANCE OF OFFSHORE HYDROCARBON PROJECTS AND WEIGHT THEIR IMPACT USING HIERARCHICAL DECISION MODEL (HDM)

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ABSTRACT

Offshore hydrocarbon projects have many different and unique characteristics, such as a larger project size, higher number of scopes, higher complexity, etc. In fact, offshore hydrocarbon projects described as mega projects are ones that require significant assessment and acquisition methods in order to reduce risks and failures. However, this paper emphasizes some critical and challenging factors that affect the successful implementation of O&G offshore projects and score these factors to highlight their weight of impact on offshore hydrocarbon projects using a hierarchical decision model (HDM). Four perspectives have been identified in order to assess these factors. These perspectives are financial, technical, geopolitics and geographic. Under each perspective, there are multiple criteria that are linked to each other with complex processes and unique challenges.

Keywords: O&G industry. Offshore hydrocarbon projects. Challenging factors.

INTRODUCTION

With the global energy demand rising every single day, offshore hydrocarbon production remains a key source of energy for meeting the worldwide energy demand. A recent report by the National Petroleum Council in the United States indicates that this sector has seen great levels of growth in the late 20th century to today, with offshore oil growing from 1% of total production in 1954 to up to 25% in 2008, and offshore natural gas observing a more steady growth, with a less dramatic rise from 1% to 11% in the same time frame [1][2]. In these days offshore hydrocarbon projects have produced about 30% of the world's oil production and 27% of world gas production since 2000 [3][4]. There are now over 7000 oil and gas installations and platforms on continental shelves in over 53 countries around the world [5][6]. Among the 30% of the world's oil production that is coming from developing offshore fields, there is around 9% that is coming from deep-water reserves projects contributions. [7][8][9]. Compared to capital projects in other industries, offshore O&G projects have many different and unique characteristics that can be challenging, such as a larger project size, higher number of scopes, higher complexity, etc. In general, offshore O&G projects tend to be significant in terms of their capital size. So called "multibillion dollar offshore O&G megaprojects" are common in industry today. Typical offshore projects also usually have a larger number of individual sub-scopes. These individual project sub-scopes are also quite large themselves with costs in the hundreds of millions of dollars. As such, these individual project sub-scopes are usually implemented or managed by multiple contractors. To develop offshore O&G projects, a large project team is formed that is comprised of various functional groups. Furthermore, regulatory requirements and the political climate can significantly influence the performance of O&G projects [4]. Because most new hydrocarbon reservoirs are discovered in ultra-deep remote waters, companies are faced with unprecedented physical, environmental, technical and project management challenges. Moreover, companies lose billions of dollars in their revenues each year due to oil spills resulting from tanker leaks, drilling well blowouts and oil spills [10]. All of these factors combined affect offshore O&G projects and lead to higher project complexity. However, as long as oil remains the lifeblood of the economy, investment in offshore exploration and production will continue, but better evaluation methods are needed to overcome all of these challenges and improve the offshore hydrocarbon projects performance.

RESEARCH OBJECTIVE

It has been observed that global offshore projects have not performed well. More than 60% of the projects experienced a cost overrun of 33% or more, schedule delays of 30% or longer, and lower than expected hydrocarbon production [11][4]. Traditionally, cash flow analysis and retain on investment are the most known factors to evaluate O&G offshore projects. However, in these days there are other factors that play a more important role in evaluating O&G offshore projects and influence investment decisions. The main purpose of this paper is to identify the key challenge factors that affect O&G offshore projects as well as assess their impact on the project's overall performance. Specific objectives of this paper include: (1) to identify the major challenging perspectives and assess their impact on O&G offshore projects. (2) Evaluate and score these factors and highlight their weight of impact on offshore hydrocarbon projects.

LITERATURE REVIEW

Through the literature review, nineteen challenge factors have been highlighted. These factors play an important role in identifying an offshore hydrocarbon project's overall performance. The nineteen factors have been captured under four perspectives including economics, technical, geopolitics, and geographic perspectives.

Oil Price Behavior

The price of a barrel of oil is one of the most important variables in determining an oil company's capital investment strategy, and oil prices have gone through many major swings since its discovery in the latter half of the nineteenth century [10]. In the history of the oil prices, there are various factors that affect the overall oil price and the industry's performance such as wars, increased production, decrease in demand and the discovery of oil shale. The history of oil price shows that the price movement is hard to predict. The oil price dropped more than 30% in a seven-month time frame in the last three decades for five times (1985– 1986, 1990–1991, 1997–1998, 2001, 2008) [12]. In the period between June 2014 and January 2015 the oil price fell by 60%, which is considered as one of the quickest and largest declines in oil history [12]. Since the offshore hydrocarbon projects cost billions of dollars, oil price remains the most important factor that affects the overall performance and yields of these projects.

Initial Cost

Oil exploration is an expensive, high-risk operation. Since, offshore projects cost a huge amount of money and deep-water wells can even cost hundreds of millions dollars, only very large corporations or national governments are capable to invest and undertake offshore and remote area exploration [13]. The capital investment for individual O&G projects has increased considerably due to the development of more challenging oil fields. The Gorgon project in Australia, which was one of the largest completed offshore projects, was estimated to cost more than $57 billion, which was almost more than double the initially estimated cost [4]. The major cost categories include engineering and project management, equipment, bulk materials, fabrication, installation, construction, startup and commissioning costs as well as the estimated cost contingency. Gaining an understanding of each cost category will help to understand the project's overall cost performance. Investments in O&G offshore projects require large monetary investments and tremendous amount of resources; hence a failure in any of its various categories can lead to a disaster. A complete and thorough analysis of all factors must be completed before pursuing a project of this sort to ensure success.

Operational Cost

Traditionally, companies have responded to low oil prices, high costs and weak margins by cancelling or postponing projects, laying off staff and freezing spending. Once the capital investments have been made, the wells have been drilled, platforms are installed, facilities commissioned and pipelines placed in service, much more remains to be done. It needs to be assured that adequate returns are being generated to match the operating expenses as this is the key to maintain production and stay in business [14]. Operational cost include staff expenditure, subsea, pollution control, water injection, maintenance, insurance, transport charges, miscellaneous etc. In O&G offshore projects operational expenses cost the companies hundreds of millions of dollars. Evaluating these operational costs in early stages and managing them effectively can significantly reduce chances of failure.

Decommissioning Cost

Offshore O&G projects generally have a lifetime of 30–40 years, and the decommissioning of offshore platforms is a major issue in the oil and gas industry [5]. Many of the offshore oil and gas facilities are now reaching the end of their productive phase, and the questions relating to shutting down production, decommissioning the production facilities and removing the redundant structures are becoming important issues for consideration [13]. In order to achieve successful decommissioning, companies need to spend a huge amount of money. Between 2010 and 2014, the Gulf of Mexico decommissioning cost was approximately US $9 billion. Over the next 30 years, almost all the 470 offshore installations in the North Sea's UK Continental Shelf, such as offshore platforms, will need to be decommissioned, according to the UK's Oil & Gas Economic Report 2013 [15]. Twenty-seven offshore oil and gas platforms in southern California will be decommissioned by 2030 as the platforms reach the end of their useful production lifetimes [16]. One of the most important steps in the decommissioning process is to plan ahead. Since decommissioning costs a huge sum of money and can affect the overall project performance, companies should set a clear strategy on how to deal with decommissioning in the very early stages of the project to avoid that burden later.

Large Size and Multiple Scopes

Offshore O&G projects tend to be significant in terms of their capital size. So called “multibillion dollar offshore O&G megaprojects” are common in the industry today. Typical offshore projects have a larger number of sub-scopes, such as well, subsea system, production system, transportation system, etc. These individual project sub-scopes are also quite large with costs in the hundreds of millions of dollars. As such, these individual project sub-scopes are usually implemented or managed by multiple contractors [4]. With rising project complexity, pressure to deliver on schedule and within budget simultaneously increase, there is a high chance for things to be missed, done incorrectly or simply not accomplished [10]. Large project size and multiple scopes is one of the more important technical factors that must be assessed and evaluated with the appropriate approach to reduce the risk of the complexity and chance of failure.

Schedule Performance

Schedule performance is also an important element in the evaluation of offshore hydrocarbon project systems at different stages. In general, the schedules of O&G projects are highly influenced by oil prices in addition to project characteristics. During periods when the oil prices are soaring, there is a huge incentive for E&P companies to deliver oil to customers in a short time in order to recover costs and maximize profit [17][4]. Since the offshore projects require a huge investment of millions of dollars, schedule performance can cause a considerable impact. However, there are several other causes leading to schedule overruns for large offshore projects. Assessing a project's sub scope level schedule is also critical in understanding individual sub scope schedules as well as that for the overall project. Delays to individual scopes can cause delays to the whole project. For example, a drilling scope delay will significantly postpone commissioning of the overall project and defer oil production.

Safety Performance

Health and safety are important elements of the industry and its working standards. Offshore petroleum projects function in unsafe environments and constantly deal with risky products. It therefor is extremely essential to ensure that all the workers working on these projects are trained to the fullest extent in dealing with relevant health and safety issues. This not only ensures their own protection, but also protection of the general public and environment [13]. Due to the nature of the work environment and the properties of the products, offshore O&G projects pose more serious safety threats to the workers than their counterparts in other industries. For example, there were 1183 fatality cases in the U.S. O&G industry between 2003 and 2013. The fatality rate is 29.1 deaths per 100,000 workers, which is eight times higher than the rate for the overall U.S. worker [18][4]. Safety performances cost companies a huge amount of money and lead to delays to the whole project. A recent example is the Deep-water Horizon accident in 2010. The gas blowout-induced explosion killed 11 workers and injured another 17 of the 126 on board [19]. The Deep-water Horizon accident is the largest blowout catastrophe on record in deep-water oil drilling history and it has already cost about $62 billion for just British Petroleum (BP) [20][21]. A project's safety performance has become a priority in determining whether an offshore O&G project is successful [4].

Operational Difficulties

Deep-water drilling is one of the high-risk operations in the oil and gas sector due to large uncertainties and extreme operating conditions [22]. Operational complications force companies to increase their spending on the project that will lead to cost overrun and schedule delays. Offshore petroleum projects face different types of operational difficulties such as, complex working equipment, harsh weather conditions, limited access to safety points, hydrocarbon releases, fire, high degrees of temperature and pressure, fatigue, etc. Therefore, deep-water drilling consists of complex operations in which engineering and commissioning mistakes, along with major work overs, can cost tens of millions of dollars [23][24]. An operational difficulty is a significant factor that can cause substantial delays to the overall project and lead to a significant loss of money and investments.

Supply-Chain

The complex nature of the oilfield supply chain and the contemporary business environments consists of high levels of uncertainty and complexity in terms of what methods and balance of practices should be considered in controlling and managing domestic international supply chains. In a supply-chain, a company is linked to its upstream suppliers and downstream distributors as materials, information, and capital flow through the supply-chain [25]. Supply chain challenges in offshore petroleum include health, safety, security and environment management and complex operations with multiple stakeholders. Challenges on supply chain could lead to other risk factors that will affect the project performance and cost such as inventory management since upstream companies do not entirely trust the reliability of deliveries of suppliers consequently, the upstream companies maintain surplus stocks to avoid stock out situations and shutdown of operations [26]. Supply chain is an important factor that impacts the whole project and it should be evaluated in the very early stage.

Human and Material Risks

In big projects such as offshore hydrocarbon projects, human and material are considered challenging factors for the companies. The complexity of the fabrication, assembly and construction of offshore drilling and accommodation facilities requires the participation of a vast team of multidisciplinary experts, including designers, engineers, geo-technical, process, structural, mechanical, marine and program managers who coordinate a myriad of sub-contractors working in geographically distributed locations [10]. On the material side, hundreds of sub-components and parts coming from different suppliers have to fit together, work according to design, be safe, and all parties have to agree on how to assemble them at the offshore location. The assembly phase resembles the piecing together of a gigantic puzzle some pieces of which weigh several thousand tons in the high seas [10]. Managing human and material resources in the right way needs to be a priority for the O&G companies to avoid any unexpected circumstances later in the process.

Government Stability

Oil and gas companies tend to prefer countries with stable political systems and a history of granting and enforcing long-term leases. However, in the past companies simply go where the oil and gas is, even if a particular country doesn't quite match their preferences. The main driving factors of investment decisions were made based on sites that were financially beneficial, leading in oil quality and their availability. Numerous issues may arise from this, including sudden nationalization and/or shifting political winds that change the regulatory environment. Depending on what country the oil is being extracted from, the deal a company starts with it is not always the deal it ends up with, as the government may change its mind after the capital is invested, in order to make more profits. An important approach that a company takes in mitigating this risk is careful analysis and building sustainable relationships with its international oil and gas partners, if it hopes to remain in there for the long run.

Conflict Over Maritime Claims

The United Nation Convention on the Law of the Sea (UNCLOS), established by the United Nations (UN) in 1984, is a quasi-constitutional treaty that grants certain areas of the Arctic seafloor to the five circumpolar nations [27]. The UNCLOS states that exclusive economic zones (EEZs) shall not extend beyond 200 nautical miles (nm) from which the breadth of the territorial sea is measured [28][29]. Based on new research "Offshore oil development and maritime conflict in the 20th century: A statistical analysis of international trends" by Elizabeth Nyman shows that the independent variable is positive and significant at the 95% confidence level, indicating that the threat or use of conflict over maritime claims with offshore oil is indeed more likely to occur in the wake of successful offshore drilling [2]. The conflict over maritime most likely occurs when the high production performance has been achieved which means that a lot of money and effort have already been put on the project, so any cancellation or delay can lead to a disaster.

Policies, Regulations and Governance Standards

Various policies governing the regulations for offshore hydrocarbon drilling have been radically changing due to fluctuating public and governmental values. Industry regulations aim at stabilizing the conditions for production and efficiency, while the fairly new paths of social regulation deal with external factors of material production, workplace health, safety and environmental security [30]. The success of a petroleum project is also greatly influenced by political uncertainty, such as changing taxes, public service announcement terms, government stability in the developing countries, etc. for example since the 1970s, the offshore oil and gas industry has been subjected to multiple environmental regulations [30]. Offshore petroleum projects have a lifetime of about 40 to 50 years, so any regulation and policy change during this time can increase the cost and cause delays.

Contracts Complexity

O&G companies are required to have a license to explore for hydrocarbons [13]. Finding the right contract that fits within the company's vision is a complicated process and requires tremendous experience in dealing with offshore O&G contracts in order for the project to be successful. However most governments have their own policies to manage bidding and contracts of O&G offshore projects. Firms have to fulfill the government regulations and policies such as environmental protection, health and safety and public opinion etc. Such processes and others make offshore O&G contracts very complicated and they require the firm to have extended experiences and strong assessment capabilities to go through this long and tedious contract and leasing process.

Geologic and Seismic Uncertainty

Enhanced understanding of the geological environment is needed in order to identify potential geo-hazards and develop technological countermeasures to hazardous precursors [32]. However, in order for the geologists to discover the oil, a process that involves shock waves or seismic waves is used in creating a picture of deep rock structures. Even though, geological and geophysical clues can be reassuring, but drilling is the only way to confirm if an oil or gas field actually exists in that location. The geologic and seismic uncertainty can cause the company to lose money and waste time and resources. Today, the average wildcat well has only one chance in ten of finding an economic accumulation of hydrocarbons. So even though oil and gas prospectors of today have better tools than their predecessors, luck remains a significant factor in the search for oil and gas [13].

Subsurface Reservoir Uncertainty

With the increasing use of petroleum, a vast number of oil-derived products are becoming more expensive to produce, including petrol, lubricating oils, plastics, tires, roads, synthetic textiles, etc. The increased oil prices and the amounts of oil reserves left on earth have encouraged researchers to develop new alternatives to these petroleum-based products. Oil reserves are primarily a measure of geological risk of the probability of oil existing and being producible under current economic conditions, using current technology. However, because of reservoir characteristics and limitations in petroleum extraction technologies, only a fraction of this oil can be brought to the surface, and it is only this producible fraction that is considered to be reserves. However, as the geology of the subsurface cannot be examined, direct or indirect techniques must be used to estimate the size and recoverability of the resource. While new technologies have increased the accuracy of these techniques, significant uncertainties still remain [13].

Production Performance

The main objective of offshore O&G projects is to extract oil and gas from the subsea underground. If the project fails to produce the planned production, it should be considered a failure because the production volume of the oil and gas is one of the key factors to determine a project's profitability and future [4]. However, production performance is often omitted when evaluating an O&G project's performance. The main reason is the fact that it usually takes 2-5 years of operations to collect enough production records to generate a production index metric. By that time, the project has been totally completed and the project team dismissed, so there is no one to take responsibility for the low production rate. Based on historical record, on average, an O&G project produces just 75% of the planned production due to various reasons, which means it lost 25% of the revenue due to project production failure [33][4]. In addition to other factors such as, cost, schedule, and safety, actual O&G production performance is also a measure of project success. Even though the O&G companies use advanced technology in drilling operation, there is still no clear way to evaluate the production performance before the well has been drilled which can cost the project a fortune if it fails.

Locations and Water Depth

Since 1994, 2,500 to 3,700 wells have been drilled each year. The number of deep-water (>400 m) wells has grown over the past 15 years while the number of shallow water (<400 m) wells has fluctuated [34]. Operations for ultra-deep wells, which the depth is between 6000 meters to 9000 meters, require advance technologies and high capabilities. In some cases, the operation drilling occurs for extremely deep wells, whose depth is more than 9000 meters which can increase the operation costs and risks [35]. In addition, the offshore projects are moving farther away from the land. For example, the Libra offshore project in Brazil is 125 miles away from Rio de Janeiro [4]. Beside the water depth challenges, drilling site and location have a significant impact on offshore projects since they increase risks. Moreover, The remote geographic locations and complexity of upstream operations in deep water locations has led to great distances for the supply chain partners. This in turn has resulted in large in-transit inventories and inventory carrying costs as the companies need to keep a greater amount of safety stock at the final location [36][37][26]. To project geographic locations and water depth are major challenges that need to be evaluated before the investment decision is made.

Environmental impacts

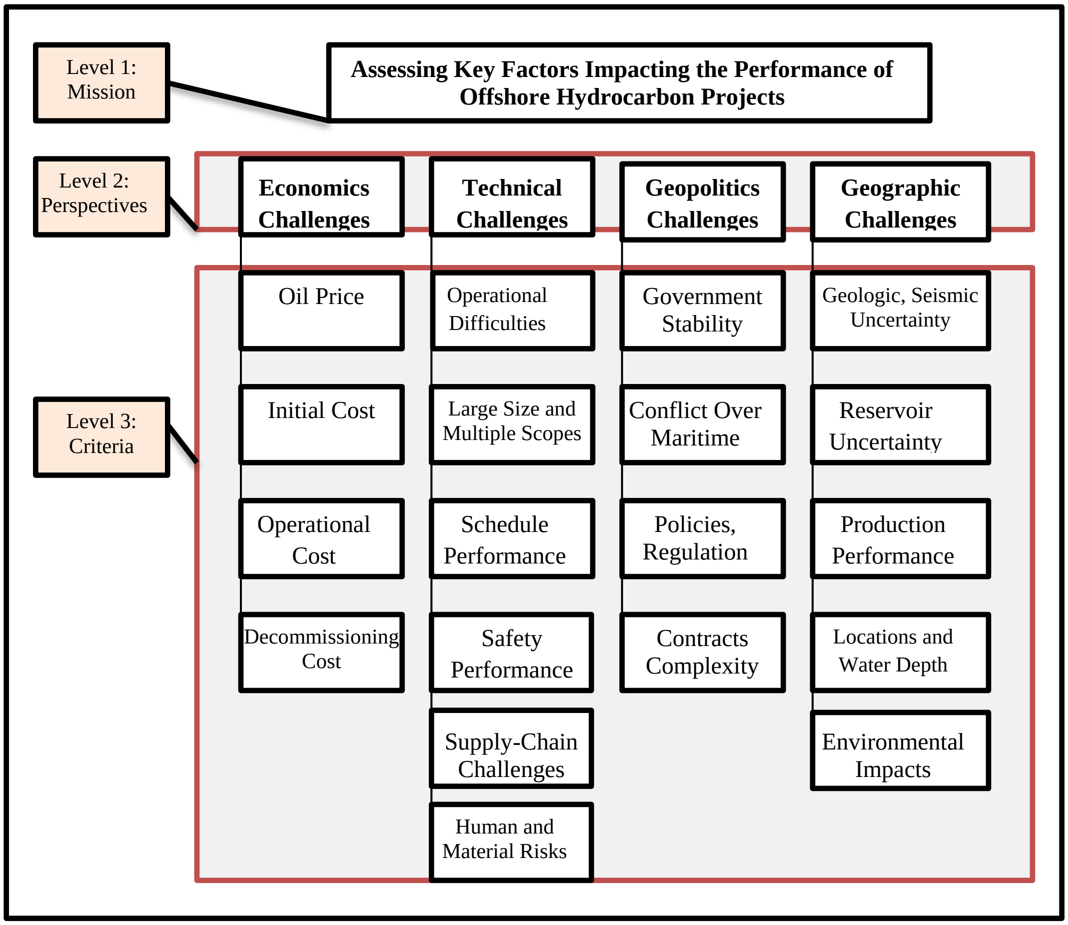
The marine environment is host to a diverse set of highly productive and complex ecosystems. In addition to playing a central role in climatic regulation, it also contributes significantly towards biodiversity maintenance, food and energy provision, and the creation of economic and cultural benefits [38][39]. Yet whilst marine systems are highly adaptive they are also vulnerable [40][41][42]. In recent years, particular attention has been directed towards the impacts caused by the offshore oil and gas industry [44][45][46][42]. Activities such as flaring, drilling, construction, transportation and discharge have all played a role in disturbing marine ecosystems [47][48]. As the offshore industry expands into the world, the oil and gas exploration activities generate all kinds of waste, varying from contaminated runoff water to material packaging; however, the majority of the waste is associated with the drilling cuttings from drilling activities [49][50][51]. These unique conditions require development of robust, internationally acceptable policies and technologies before renewed interest in exploitation occurs [52][53][29]. A significant oil spill in marine waters could have extensive and long-term impacts. Abilities to respond to oil spills are extremely limited, posing significant challenges for implementing pollution prevention techniques [54]. Furthermore, there are few effective technologies to contain and clean up oil spills [29]. Based on environmental impacts and climate change, the offshore O&G industry is subjected to new policies and regulations that will increase investment costs and delay production productivity.

METHODOLOGY

This paper emphasizes the critical and challenging factors that affect the implementation of O&G offshore projects and their overall performance. The methodology that has been used in this research is the Hierarchical Decision Model (HDM) that was introduced by Cleland and Kocaoglu [55]. This Model has abbreviation (MOGSA), which is invented by Dr. Kocaoglu. In HDM, the subjective judgments expressed in pairwise comparisons are converted to relative weights in ratio scale. This is done by a series of mathematical operations on three matrices. The methodology can be used for quantifying the judgment of a single decision maker, or multiple decision makers. HDM links the decision elements at multiple levels of organizational entities, in which decisions at the operational level are made in support of higher level goals and objectives, and when the objectives are met, the final results of the operational decisions are transformed into benefits for the organization [56]. The HDM method has several advantages and strengths. For instance, if the decision maker finds and has access to experts, all the reasoning and analyses will rest upon their opinions, what makes the outcome highly trustworthy. Furthermore, one of the biggest barriers in the decision-making process is to translate qualitative data into quantitative information (much easier to assess), and HDM is a great way of doing this - it has the ability to interpret subjective aspects of a problem in order to analyze it objectively. However, during the data collection phase, it is important to consider inconsistency and disagreements among the judgments' of experts. Inconsistency is a disagreement within an individual's evaluation, which in other words shows how an expert could have an inconsistent judgment within his/her comparisons. Disagreements amongst experts can show different quantifications and different perspectives to the same analysis.

DEVELOPMENT OF THE RESEARCH MODEL

The decision model was based on the comprehensive literature review that was described in the previous paragraph. Four perspectives have been identified in order to assess these factors. These perspectives are financial, technical, geopolitics and geographic. Under each perspective there are multiple criteria that are linked to each other with complex processes and unique challenges. An assessment of these challenges associated with O&G offshore projects lead to reduced risk and increased the probability of success. Prospects in offshore petroleum projects encounter several challenges such as, huge costs, operational difficulties, human and material risks, geologic uncertainty, large project size with multiple scopes, safety concern, regulations and environmental impacts. Figure 1 illustrates the finalizing model.



Expert Panel Formation

The research relies on the experts and their willingness to contribute. Seven experts showed interest to participate. All experts were contacted via email or phone to determine their ability and willingness to participate. Five panels have been formed in order to capture the expert's judgment based on their experience and area of interest.

- Expert panel P0 was formed to validate the literature based hierarchical decision model. The experts were selected based on their expertise in the offshore O&G field.
- Expert panel P1 was formed to quantify the perspective level and its contribution to the decision level.
- Expert panel P2 was formed to quantify the economic perspective of the model.
- Expert panel P3 was formed to quantify the technical perspective of the model.
- Expert panel P4 was formed to quantify the political perspective of the model.
- Expert panel P5 was formed to quantify the geographic perspective of the model.

Table 1 and Table 2 illustrate the expert panels' breakdown and each expert's background including the time of experience in the industry, current positions and area of interest.

Panel	Panel Focus
P0	Model Validation
P1	Perspective Level Quantification
P2	Economic Factors
P3	Technical Factors
P4	Political Factors
P5	Geographic Factors

Expert Panels Breakdown: Table 1

Expert	Background		P0	P1	P2	P3	P4	P5
	Time of Experience	Current Position						
Expert 1	42 Years	Production Manager		X	X	X	X	X
Expert 2	30 Years	JPT Director Mellitah O&G BV	X	X	X			X
Expert 3	15 Years	Offshore Coordinator Mellitah Gas BV	X	X		X		
Expert 4	14 Years	HSEQ Coordinator: Bahr Essalam Phase II- Offshore Project Mellitah Oil & Gas BV	X	X	X	X		
Expert 5	11 Years	Projects Interface Coordinator.	X	X			X	X
Expert 6	10 Years	Sustainable Development Project Manager	X	X	X	X		
Expert 7	10 Years	Projects Coordinator Mellitah O&G BV	X	X			X	X

Background of the Experts: Table 2

RESULTS OF MODEL QUANTIFICATION

Content Validation

Panel P0 consisted of six experts who responded and agreed to validate the model. All of the participants had a broad understanding of offshore O&G projects. They are senior level personnel who have extensive experience not less than 10 years working in this field. The panel was asked to comment on the model structure and content. The assessment tool was intended to capture their judgment of the suitability of the proposed perspectives and success attributes, and identify those that might have gone undetected during the literature review. All of the experts agreed that majority of the factors affecting the O&G offshore projects have been captured. However, the experts provided some comments and suggestions that do not affect the model validation.

Data collection

Perspective level quantification (Panel 1): Panel P1 consisted of 7 participants. They were asked to compare the contribution of the four perspectives to the overall research objective of identifying the key challenge factors that affect O&G offshore projects. The experts completed six comparisons to determine the output shown in Tables 3.

Experts	Economics Challenges	Technical Challenges	Political Challenges	Geographic Challenges	Inconsistency
1	0.38	0.19	0.29	0.14	0
2	0.3	0.16	0.23	0.31	0.01

3	0.43	0.31	0.17	0.09	0.08
4	0.24	0.16	0.43	0.17	0.03
5	0.24	0.17	0.4	0.19	0
6	0.3	0.26	0.24	0.2	0
7	0.32	0.24	0.32	0.12	0
Mean	0.32	0.21	0.3	0.17	
Minimum	0.24	0.16	0.17	0.09	
Maximum	0.43	0.31	0.43	0.31	
Std. Deviation	0.06	0.05	0.09	0.07	
Disagreement					0.064

The inconsistency within each expert is acceptable (all < 0.10). Based on this panel's results, the economics perspective is assessed as the most important factor with (0.32) score followed by political perspective with (0.3) score.

Economic Factors (Panel 2): Panel P2 consisted of 4 participants. They were asked to assess the relative contribution of the four success attributes to the Economics perspective. The experts completed six comparisons to determine the output shown in Tables 4.

Experts	Oil Price	Initial Cost	Operational Cost	Decommissioning Cost	Inconsistency
1	0.47	0.26	0.18	0.09	0
2	0.39	0.12	0.31	0.17	0.02
3	0.3	0.23	0.28	0.2	0
4	0.39	0.26	0.22	0.13	0
Mean	0.39	0.22	0.25	0.15	
Minimum	0.3	0.12	0.18	0.09	
Maximum	0.47	0.26	0.31	0.2	
Std. Deviation	0.06	0.06	0.05	0.04	
Disagreement					0.051

The inconsistency within each expert is acceptable (all < 0.10). Based on this panel, oil price criteria is assessed as the most important factor with a score of (0.39).

Technical Factors (Panel 3): Panel P3 consisted of 4 participants. They were asked to assess the relative contribution of the six success attributes to the Technical perspective. The experts completed fifteen comparisons to determine the output shown in Tables 5.

Experts	Operational Difficulties	Large Size, Multiple Scopes	Schedule Performance	Safety Performance	Supply Chain Challenges	Human, Material Risks	Inconsistency
1	0.15	0.17	0.12	0.25	0.09	0.21	0
2	0.14	0.17	0.12	0.28	0.09	0.21	0
3	0.22	0.15	0.2	0.14	0.14	0.14	0
4	0.15	0.13	0.17	0.21	0.15	0.19	0.01
Mean	0.17	0.16	0.15	0.22	0.12	0.19	
Minimum	0.14	0.13	0.12	0.14	0.09	0.14	
Maximum	0.22	0.17	0.2	0.28	0.15	0.21	
Std. Dev.	0.03	0.02	0.03	0.05	0.03	0.03	
Disagreement							0.032

The inconsistency within each expert is acceptable (all < 0.10). Based on this panel, safety performance criteria is assessed as most the important factor with a score of (0.22).

Political Factors (Panel 4): Panel P4 consisted of 3 participants. They were asked to assess the relative contribution of the four success attributes to the Political perspective. The experts completed six comparisons to determine the output shown in Tables 6.

Experts	Government Stability	Conflict Over Maritime Claims	Policies, Regulations and Governance Standards	Contracts Complexity	Inconsistency
1	0.38	0.17	0.25	0.2	0
2	0.3	0.25	0.26	0.18	0.09
3	0.38	0.19	0.26	0.16	0.01
Mean	0.35	0.2	0.26	0.18	
Minimum	0.3	0.17	0.25	0.16	
Maximum	0.38	0.25	0.26	0.2	
Std. Dev.	0.04	0.03	0	0.02	
Disagreement					0.026

The inconsistency within each expert is acceptable (all < 0.10). Based on this panel, government stability criteria is assessed as the most important factor with a score of (0.35).

Geographic Factors (Panel 5): Panel P5 consisted of 4 participants. They were asked to assess the relative contribution of the five success attributes to the Geographic perspective. The experts completed ten comparisons to determine the output shown in Tables 7.

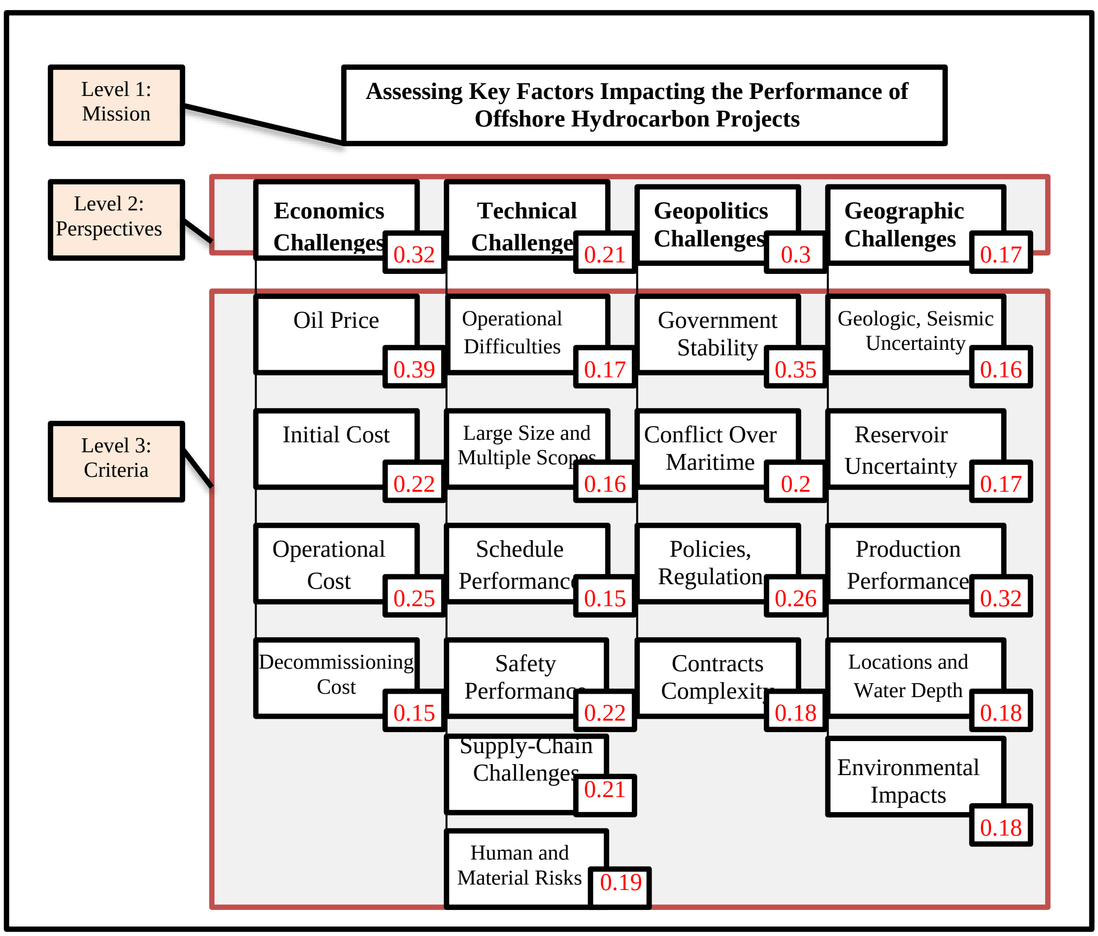
Experts	Geologic, Seismic Uncertainty	Subsurface Reservoir Uncertainty	Production Performance	Locations and Water Depth	Environmental Impacts	Inconsistency
1	0.1	0.12	0.44	0.15	0.18	0
2	0.2	0.22	0.18	0.23	0.18	0.08
3	0.2	0.22	0.29	0.16	0.14	0
4	0.14	0.12	0.35	0.18	0.21	0
Mean	0.16	0.17	0.32	0.18	0.18	
Minimum	0.1	0.12	0.18	0.15	0.14	
Maximum	0.2	0.22	0.44	0.23	0.21	
Std. Dev.	0.04	0.05	0.09	0.03	0.02	
Disagreement						0.052

The inconsistency within each expert is acceptable (all < 0.10). Based on this panel, production performance criteria is assessed as most important factor with a score of (0.32).

Final Model Weights

The output of experts' judgment quantification has been summarized in Table 8 and Figure 2. The most important perspective is economic with a score of 0.32 and the corresponding most important success attribute is oil price (0.39). The experts scored political as the second most important perspective with a value of 0.3 and indicated that it is affected by government stability criterion that has a value of 0.35. Nevertheless, production performance, policies, regulations and governance standards, operational cost, safety performance and initial cost have high impacts on offshore hydrocarbon project's overall performance based on these expert's judgment quantification.

Perspectives	Value	Criteria	Value	Contribution of each criterion to the whole project through the perspectives.
Economics Challenges	0.32	Oil Price	0.39	0.120
		Initial Cost	0.22	0.070
		Operational Cost	0.25	0.080
		Decommissioning Cost	0.15	0.050
Technical Challenges	0.21	Operational Difficulties	0.17	0.040
		Large Size and Multiple Scopes	0.16	0.030
		Schedule Performance	0.15	0.030
		Safety Performance	0.22	0.050
		Supply-Chain Challenges	0.12	0.030
		Human and Material Risks	0.19	0.040
Political Challenges	0.3	Government Stability	0.35	0.100
		Conflict Over Maritime Claims	0.2	0.060
		Policies, Regulations and Standards	0.26	0.080
		Contracts Complexity	0.18	0.050
Geographic Challenges	0.17	Geologic and Seismic Uncertainty	0.16	0.030
		Subsurface Reservoir Uncertainty	0.17	0.030
		Production Performance	0.32	0.050
		Locations and Water Depth	0.18	0.030
		Environmental Impacts	0.18	0.030
Total	1			1.000



CONCLUSION

The global energy sector relies heavily on offshore hydrocarbon projects. They have produced about 30% of the world's oil production and 27% of world gas production since 2000 [3][4]. There are now over 7000 oil and gas installations and platforms on continental shelves in over 53 countries around the world [5][6]. However, global offshore projects have not performed well. More than 60% of the projects experienced a cost overrun of 33% or more, schedule delays of 30% or longer, and lower than expected hydrocarbon production [11][4]. The results of this research provide valuable information and a better assessment to aid the process of decision-making. The literature and model framework defined multiple perspectives including economics, technical, geopolitics, and geographic. Under these perspectives there were nineteen factors that impact the overall performance of offshore O&G projects. The results of this research introduced values and scores for each perspective and criterion in order to provide better evaluation and understanding to these factors and their impact on the projects. Oil price, government stability and production performance have a higher impact on the success of an offshore hydrocarbon project. These factors must be significantly evaluated before the project kick-off.

LIMITATIONS

Seven influential experts who have at least 10 years of working experience in the O&G industry indicated their interest and participated in this research. However, more number of experts can provide a more intensive and detailed evaluation of the four perspectives. Moreover, performing a case study will help obtain more accurate results since Oil and Gas offshore companies have different abilities and circumstances to implement their projects. Finally, considering and adding more factors that impact the performance of hydrocarbon offshore project to this model such as social, stockholders, etc. will enhance the results of this study.

REFERENCES

[1] "NPC. Offshore oil and gas supply," presented at the National Petroleum Council, Washington, DC, 2011.

[2] E. Nyman, "Offshore oil development and maritime conflict in the 20th century: A statistical analysis of international trends," *Energy Res. Soc. Sci.*, vol. 6, pp. 1–7, Mar. 2015.

[3] Maribus, Exzellenzcluster Ozean der Zukunft, and International Ocean Institute, Eds., *Marine resources - opportunities and risks*. Hamburg: maribus, 2014.

[4] Z. Rui *et al.*, "Development of industry performance metrics for offshore oil and gas project," *J. Nat. Gas Sci. Eng.*, vol. 39, pp. 44–53, Mar. 2017.

[5] Y. Tan, Y. Song, X. Liu, X. Wang, and J. C. P. Cheng, "A BIM-based framework for lift planning in topsides disassembly of offshore oil and gas platforms," *Autom. Constr.*, vol. 79, pp. 19–30, Jul. 2017.

[6] S. T. Orszulik, Ed., *Environmental technology in the oil industry*, 2. ed. Dordrecht: Springer, 2008.

[7] A. Shukla and H. Karki, "Application of robotics in offshore oil and gas industry— A review Part II," *Robot. Auton. Syst.*, vol. 75, pp. 508–524, Jan. 2016.

[8] R. Sandrea and I. Sandrea, "Deepwater crude oil output: How large will the uptick be?," *Oil Gas J 108*, pp. 48–48, 2010.

[9] J. Ferentinos, "Global offshore oil and gas outlook," 2013.

[10] P. M. Doherty and D. Systemes, "The Economics, Execution and Management of Complex Offshore Projects," *Offshore Technology Conference*, pp. 1–11, May 2011.

[11] E. W. Merrow, "Oil and Gas Industry Megaprojects: Our Recent Track Record," *Oil Gas Facil.*, vol. 1, no. 2, pp. 38–42, Apr. 2012.

[12] D. Fantazzini, “The oil price crash in 2014/15: Was there a (negative) financial bubble?,” *Energy Policy*, vol. 96, pp. 383–396, Sep. 2016.
[13] M. Holmager, M. Redda, and J. C. Design, *Offshore Book: An introduction to the offshore industry*. Offshore Center Danmark, 2010.
[14] P. K. Verma and A. K. Srinivasan, “Operating Cost Optimisation: Importance & Approach,” presented at the 7 th International Conferenve & Exposition on Petroleum Geophysics, 2008, vol. 7, pp. 1–7.
[15] “Economic Report, Oil & Gas UK,” 2013.
[16] M. Henrion, B. Bernstein, and S. Swamy, “A multi-attribute decision analysis for decommissioning offshore oil and gas platforms: Decision Tool for Decommissioning Offshore Oil Platforms,” *Integr. Environ. Assess. Manag.*, vol. 11, no. 4, pp. 594–609, Oct. 2015.
[17] EY, “Spotlight on Oil and Gas Megaprojects,” *Ernst Yong UK*, 2014.
[18] K. Retzer and R. Hill, “Fatalities in the U.S. Oil & Gas Extraction Industry,” *Fireline*, pp. 1–6, 2016.
[19] S. Rathnayaka, F. Khan, and P. Amyotte, “Accident modeling approach for safety assessment in an LNG processing facility,” *J. Loss Prev. Process Ind.*, vol. 25, no. 2, pp. 414–423, Mar. 2012.
[20] B. Cai, Y. Liu, Z. Liu, X. Tian, Y. Zhang, and R. Ji, “Application of Bayesian Networks in Quantitative Risk Assessment of Subsea Blowout Preventer Operations: Bayesian Networks in Quantitative Risk Assessment,” *Risk Anal.*, vol. 33, no. 7, pp. 1293–1311, Jul. 2013.
[21] J. Bhandari, R. Abbassi, V. Garaniya, and F. Khan, “Risk analysis of deepwater drilling operations using Bayesian network,” *J. Loss Prev. Process Ind.*, vol. 38, pp. 11–23, Nov. 2015.
[22] A. Albert, O. M. Aamo, J.-M. Godhavn, and A. Pavlov, “Suppressing Pressure Oscillations in Offshore Drilling: Control Design and Experimental Results,” *IEEE Trans. Control Syst. Technol.*, vol. 23, no. 2, pp. 813–819, Mar. 2015.
[23] D. Rich, B. Rogers, W. Dyson, K. Olson, J. Smart, and D. Tiffin, “GoM deepwater completions—the devil is in the details,” presented at the offshore technology conference, Houston, USA, 2010.
[24] J. E. Skogdalen and J. E. Vinnem, “Quantitative risk analysis of oil and gas drilling, using Deepwater Horizon as case study,” *Reliab. Eng. Syst. Saf.*, vol. 100, pp. 58–66, Apr. 2012.
[25] R. Sharma, M. Agarwal, and M. Lixin, “Challenges in Supply Chain Management in Upstream Sector of Oil and Gas Industry,” presented at the Agro Supply Chain Conference (ASCC), University of Petroleum & Energy Studies,Dehradun, 2016, pp. 1–17.
[26] C. Herrera, “Outsourcing Logistics in the oil and gas Industry,” May 2012.
[27] J. Ellis, “Law of the sea convention, Essential Concepts of Global Environmental Governance,” 2014, vol. 113.
[28] United Nations General Assembly. Convention of the Law of the Sea. 1982. Retrieved from: http://www.refworld.org/docid/3dd8fd1b4.html (accessed 17.03.16).
[29] S. Gulas, M. Downton, K. D’Souza, K. Hayden, and T. R. Walker, “Declining Arctic Ocean oil and gas developments: Opportunities to improve governance and environmental pollution control,” *Mar. Policy*, vol. 75, pp. 53–61, Jan. 2017.
[30] P. Clancy, “Offshore Petroleum Politics: A Changing Frontier in a Global System,” *Policy Soc.*, vol. 26, no. 1, pp. 113–134, Jan. 2007.
[31] D. Fant, “An Analysis and Evaluation of Rules and Procedures Governing OCS Operations,” presented at the American Bar Association, Washington, DC, 1990.
[32] “Advancing Systems and Technologies to Produce Cleaner Fuels,” in *Offshore Safety and Spill Prevention*, QuadrennialTechnologyReview2015, 2015.
[33] N. Nandurdikar and L. Wallace, “Failure to Produce: an Investigation of Deficiencies in Production Attainment,” in *SPE ATCE*, Colorado, USA, 2011.
[34] M. J. Kaiser, B. Snyder, and A. G. Pulsipher, “Offshore Drilling Industry and Rig Construction Market in the Gulf of Mexico,” Cooperative Agreement Coastal Marine Institute Louisiana State University, BOEM 2013-0112, Mar. 2013.
[35] H. Mao, Z. Qiu, B. Xie, Z. Wang, Z. Shen, and W. Hou, “Development and Application of Ultra-High Temperature Drilling Fluids in Offshore Oilfield Around Bohai Sea Bay Basin, China,” 2016.
[36] A. Selot, “Short-Term Supply Chain Management in Upstream Natural Gas Systems,” 2009.
[37] J. Brown, “Fueling the Oil and Gas Supply Chain,” Jul. 2014.

[38] F. Douvere, “The importance of marine spatial planning in advancing ecosystem-based sea use management,” *Mar. Policy*, vol. 32, no. 5, pp. 762–771, Sep. 2008.
[39] S. Kidd, A. Plater, and C. Frid, “The ecosystem approach to marine planning and management,” presented at the Earthscan, London, 2011.
[40] B. S. Halpern, K. A. Selkoe, F. Micheli, and C. V. Kappel, “Evaluating and Ranking the Vulnerability of Global Marine Ecosystems to Anthropogenic Threats,” *Conserv. Biol.*, vol. 21, no. 5, pp. 1301–1315, Oct. 2007.
[41] M. Ruckelshaus, T. Klinger, N. Knowlton, and D. P. DeMASTER, “Marine Ecosystem-based Management in Practice: Scientific and Governance Challenges,” *BioScience*, vol. 58, no. 1, p. 53, 2008.
[42] A. Barker and C. Jones, “A critique of the performance of EIA within the offshore oil and gas sector,” *Environ. Impact Assess. Rev.*, vol. 43, pp. 31–39, Nov. 2013.
[43] D. A. Holdway, “The acute and chronic effects of wastes associated with offshore oil and gas production on temperate and tropical marine ecological processes,” *Mar. Pollut. Bull.*, vol. 44, no. 3, pp. 185–203, Mar. 2002.
[44] G. Huppes, M. D. Davidson, J. Kuyper, L. van Oers, H. A. Udo de Haes, and G. Warringa, “Eco-efficient environmental policy in oil and gas production in The Netherlands,” *Ecol. Econ.*, vol. 61, no. 1, pp. 43–51, Feb. 2007.
[45] J.-P. Ducrotoy and M. Elliott, “The science and management of the North Sea and the Baltic Sea: Natural history, present threats and future challenges,” *Mar. Pollut. Bull.*, vol. 57, no. 1–5, pp. 8–21, Jan. 2008.
[46] Salter E, Ford J. Holistic environmental assessment and offshore oil field exploration and production. *Mar Pollut Bull* 2001;42 (1):45–58.
[47] F. K. Wiese, W. . Montevecchi, G. . Davoren, F. Huettmann, A. . Diamond, and J. Linke, “Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic,” *Mar. Pollut. Bull.*, vol. 42, no. 12, pp. 1285–1290, Dec. 2001.
[48] T. Geehan, A. Gilmour, and Q. Guo, “The Cutting Edge in Drilling Waste Management,” 2007.
[49] Z. Ayele, A. Barabadi, and J. Barabady, “Drilling Waste Handling and Management in the High North,” presented at the IEEE International Conference on Industrial Engineering and Engineering Management, Bangkok, Thailand, 2013, pp. 673–678.
[50] Y. Z. Ayele, A. Barabadi, and E. L. Droguett, “Risk-Based Cost-Effectiveness Analysis of Waste Handling Practices in the Arctic Drilling Operation,” *J. Offshore Mech. Arct. Eng.*, vol. 138, no. 3, p. 31301, Apr. 2016.
[51] W. Amos, “Development of Canadian Arctic Offshore Oil and Gas Drilling: Lessons from the Gulf of Mexico: CANADIAN ARCTIC OFFSHORE OIL AND GAS DRILLING,” *Rev. Eur. Community Int. Environ. Law*, vol. 20, no. 1, pp. 39–46, Apr. 2011.
[52] C. Fidler and B. Noble, “Advancing strategic environmental assessment in the offshore oil and gas sector: Lessons from Norway, Canada, and the United Kingdom,” *Environ. Impact Assess. Rev.*, vol. 34, pp. 12–21, Apr. 2012.
[53] M. Knol and P. Arbo, “Oil spill response in the Arctic: Norwegian experiences and future perspectives,” *Mar. Policy*, vol. 50, pp. 171–177, Dec. 2014.
[54] D. F. Kocaoglu, “A participative approach to program evaluation,” *IEEE Trans. Eng. Manag.*, vol. EM-30, no. 3, pp. 112–118, 1983.
[55] T. U. Daim and D. F. Kocaoglu, Eds., *Hierarchical decision modeling: essays in Honor of Dundar F. Kocaoglu*. Cham: Springer, 2016.