Contracting and Innovation in Megaprojects

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Summary

Over the past decade, the field of project management has increasingly focused on understanding the balance between two distinct forms of learning within megaproject organizations: one centered on exploiting existing project capabilities and another aimed at exploring innovations. However, there remains a gap in comprehending how contractual arrangements can effectively promote ambidextrous activities that balance exploitation and exploration in projects, especially beyond the scope of partnering arrangements. This thesis seeks to bridge this knowledge gap by investigating the use of innovative contracting strategies to tap into contractors' insights regarding innovations implemented in previous projects. It adopts a multiple case study approach, with a specific emphasis on offshore oil and gas projects situated on the Norwegian Continental Shelf. The research includes 67 semi-structured interviews with insights from 72 informants. Within this thesis, three distinctive contracting approaches emerge: front-end studies (comprising appraisal, feasibility, conceptual, and FEED studies), two-stage tendering, and a suite of relational governance mechanisms employed to enhance collaboration within megaproject coalitions. These innovative contracting strategies enable better management of megaproject innovation, allowing oil companies to both leverage the supply industry's experience and explore alternative solutions for optimizing their new offshore fields. The findings are organized in papers according to different megaproject lifecycle phases: first, when the utility of innovative ideas is at its highest (paper 1); then, as innovation gradually shifts to more practical issues like construction optimization (paper 2); and finally, during the development phase, when innovation generally entails a change in project routines to cope with opportunities and challenges (paper 3).

1. Introduction

Megaprojects are a class of large-scale and multibillion-dollar projects which have the potential to transform cities and impact the lives of millions of people (Flyvbjerg, 2014; Merrow, 2011; Miller and Lessard, 2000). The typical outputs of megaprojects are characterized as one-off and highly customized infrastructure assets. Examples include airports, bridges, tunnels, roads, rail transit systems, power plants, refineries, seaports, and mining sites. Central to this list are also installations for extracting oil and gas offshore, which, as an indication of their size, can consume as much energy to operate as small cities.

One of the enduring and central challenges faced by megaprojects is effectively balancing established organizational routines with the pursuit of innovation (Liu and Leitner, 2012; Liu, Wang and Sheng, 2012). As emphasized by Stinchcombe and Heimer (1985), the efficiency in managing megaprojects derives from stable and repetitive routines that have been developed over time. However, the imperative to keep abreast of evolving regulations, technologies, and public demands necessitates a more radical approach to learning, which complements the routine-based exploitation (Sergeeva and Ali, 2020). This requirement is particularly critical in the context of megaprojects, where demand is sporadic and can span several years. During such intervals, various innovations may emerge, and project organizations must be adept at identifying and assessing these innovations, considering their relevance to the specific characteristics of the ongoing project.

Project studies have suggested several strategies for exploiting short-term efficiencies and exploring long-term innovations simultaneously (Eriksson and Szentes, 2017). This balance, commonly referred to as ambidexterity, plays a pivotal role in enhancing project performance by allowing organizations to capitalize on knowledge from past projects while fostering innovations that can significantly transform project outcomes. Ambidexterity has garnered attention from project studies utilizing various perspectives (Liu and Leitner, 2012; Sailer, 2019; Sergeeva and Ali, 2020; Sun et al., 2020; Turkulainen and Ruuska, 2022; Turner et al., 2014). Among them, contracting and collaboration have emerged as an area of interest in project ambidexterity research (Davies, Dodgson, and Gann, 2016; Eriksson, 2013; Eriksson and Szentes, 2017; Liu et al., 2022).

However, despite some studies on ambidexterity mentioning contracting as an important mechanism, there remains a limited understanding of how exploration and exploitation can be facilitated in project relationships through innovative contractual arrangements. This knowledge gap primarily stems from the prevailing emphasis on multiparty and partnering agreements (Davies, Dodgson, and Gann, 2016; Eriksson 2013; Eriksson and Szentes, 2017), which has led to an oversight of the potential benefits introduced by new contracting strategies in megaprojects.

This thesis aims to address this gap by analyzing how contracting innovations impact joint exploration and exploitation in megaprojects. The three included papers examine various aspects of ambidexterity and novel forms of contracting. The first paper examines how early contractor involvement facilitates exploration and exploitation during the front-end phases of megaprojects. The second paper investigates the factors that explain the adoption of two-stage tendering and its influence on ambidexterity. The third paper examines the processes project organizations can employ to achieve a balance between routine and innovative actions in complex project coalitions.

The ambition of this thesis is to analyze contracting as both a form of and an enabler of innovation. New forms of contracting have been adopted in the last three decades to transform how megaprojects are designed, built, operated, maintained and financed (Barlow, 2000; Halman and Braks, 1999; Miller and Floricel, 2000; van de Velde and ten Heuvelhof, 2008). Their dissemination across different sectors is an innovation in itself. On the other hand, contracting is an important mechanism for exploring innovations, where megaproject clients can dictate how much freedom or incentives suppliers have to bring forth new ideas (Clegg, Bjørkeng and Pitsis, 2011; Gil, 2009; Pakkala, de Jong and Äijö, 2007).

The twofold relationship between contracting and innovation is investigated empirically through a multiple case study of offshore oil and gas large and mega projects in the Norwegian Continental Shelf, totaling 67 semi-structured interviews with 72 informants. The innate difficulties of extracting oil in the middle of the ocean have made the offshore industry a sector historically dominated by megaprojects. Considering only the last twenty years, there has been a stream of megaprojects with high profile in the Norwegian continental shelf, such as Goliat, Martin Linge, Edvard Grieg, Ivar Aasen, Gina Krog, Aasta Hansteen, Johan Sverdrup, and Johan Castberg. The continuous demand for megaprojects provides unique opportunities for operators to experiment with new contracts and improve how they effectively govern multi-firm innovation processes.

Oil companies were the first organizations to systematically adopt collaborative delivery models, the most prominent example being the partnering approach promoted in the UK sector of the North Sea in the 1990s (Barlow, 2000; Green and Keogh, 2000; Halman and Braks, 1999). After that, oil companies have continued to advance novel forms of contracts and collaboration beyond the framework of partnering (Berends, 2006; Moazzami et al., 2015; Sabel and Herrigel, 2019). This research turned to this pioneering industry once more, to examine new contracting developments in the specialized domains of offshore megaprojects.

The three papers within this thesis explore distinct contracting strategies that facilitate innovation within megaproject organizations. The first paper investigates the utilization of front-end studies, enabling oil companies to assess numerous innovation ideas in collaboration with multiple contractors during the initial phases of the front-end. The second paper outlines the optimization of design through the implementation of two-stage tendering. In contrast, the third paper examines contracting innovations aimed at promoting adaptability and responsiveness within complex project coalitions.

2. Theoretical discussion

2.1. Megaproject innovation

From an organizational perspective, projects and innovation are closely associated (Brady and Hobday, 2011). Unlike operational activities, which are repetitive and ongoing, projects are unique, novel and transient initiatives to create new or improved products, services and business models (Shenhar and Dvir, 2007; Turner and Müller, 2003). No two projects are exactly the same; they are always delivered to bespoke designs, always achieving something new (Keegan and Turner, 2002).

However, inside projects there will always be standardized processes, repetitive behaviors, and preferences for doing things a certain way (Davies and Brady, 2004b; Obstfeld, 2012). Project innovation means introducing change to ongoing project routines. It can be a new way of organizing, a new technology, a new service, a new design, a new process, and more.

Megaproject innovation follows the same logic. Like regular projects, they are innovative because their typical outputs are one-off and customized physical assets (Miller, Lessard and Sakhrani, 2017; Williams, Samset & Sunnevåg, 2009). However, the outcome of megaproject innovation, per se, has to do with the incorporation of new ideas, practices and technologies (Davies, Gann and Douglas, 2009; Gann, Davies and Dodgson, 2017; Davies et al., 2014).

Innovation in megaprojects is a multifaceted concept, as Cantarelli and Genovese (2021) highlight in their research. The authors draw attention to two fundamental distinctions in innovation outcomes: radical and incremental innovations, which are already widely recognized in strategic management and innovation fields. While incremental innovations center on reinforcing existing products and processes, radical innovations entail disruptive changes or a complete departure from established methods and techniques. This dichotomy can be likened to the contrast between exploitation and exploration, where incremental innovations reflect exploitation, and radical innovations exemplify exploration. Cantarelli and Genovese (2021) also examine various forms of innovation, encompassing products and services, management methods and approaches, and business models. Moreover, innovations are classified based on their novelty to the firm, industry, or the world, while also encompassing both technical and administrative dimensions.

2.2. Exploring innovations and exploiting routines in megaprojects

Project management has evolved to encompass various methodologies and practices that aim to ensure predictability and control in projects. However, in the pursuit of radical innovation with uncertain goals, traditional project management standards may become inadequate (Lenfle, 2008, 2016; Lenfle and Loch, 2010). In the project management literature, a distinction is drawn between regular projects and exploratory projects, characterized by their focus on innovation. While regular projects follow canonical project management methodologies that prioritize predictability and control, exploratory projects must embrace flexibility and adaptability required for innovation (Lenfle, 2016). Recognizing this fundamental difference is crucial for organizations to appropriately analyze their project portfolios and find the right balance between exploratory and regular projects.

In the context of megaprojects, innovation is not easy to promote nor to achieve. Aside from their physical scale and excessive costs, megaprojects also take many years to be delivered, and have numerous stakeholders with power to influence the decision-making process (Flyvbjerg, 2014; Merrow, 2011; Miller and Lessard, 2000; Shenhar and Holzmann, 2017). Furthermore, the risks of performance and strategic failure in megaprojects are extremely high (e.g., Flyvbjerg, 2014; Flyvbjerg, Bruzelius, and Rothengatter 2003; Morris and Hough 1987), which means that there is a recursive tension between innovation and risks.

Managing megaprojects with flexibility to foster disruptive innovation, as if they were essentially exploratory projects, can be particularly challenging. The concept of fragility in megaprojects helps to understand why strict control and risk management are a fundamental requirement. According to Merrow (2011, p. 50), a strange pattern for megaprojects is that they do not slowly degrade toward poor outcomes but tend to collapse instead, which means that if one part of the megaproject fails, the whole effort is likely to fail altogether. Hence, it is not surprising that a conservative, risk-averse mentality is often observed among project actors, who tend to stick to what they know – the same techniques, routines and proven technologies. As a result, efforts to innovate are discouraged because they are associated with uncertainty and failure (Gil, Miozzo and Massini, 2012; Davies, Gann, and Douglas 2009).

Combining exploration and exploitation efforts becomes critical in the context of megaprojects because while at the same time that routines and management methodologies are suited for its complexity and risks, megaprojects fail if organizations become unable to innovate. Unforeseen challenges are likely to emerge during a megaproject's long lifespan, as well as opportunities for improving the business case (Gil and Beckman, 2009). Megaproject organizations must remain innovative to deal with those issues (Davies et al, 2014; Davies, MacAulay and Brady, 2019; Gann, Davies and Dodgson, 2017). Therefore, a careful equilibrium must be struck to ensure that essential elements of predictability and control are not compromised during the pursuit of innovation. To navigate the challenges posed by balancing exploratory and exploitative projects in the context of megaprojects, the concept of ambidexterity comes into play.

2.3. Project ambidexterity and contracting

In the last decade, the balance between exploration and exploitation has gained increasing importance and attention in the project management field, as researchers work to develop strategies and frameworks that empower project teams to foster ambidextrous capabilities. Studies on project ambidexterity offer a diverse range of perspectives, including explorations into its conceptual underpinnings, empirical examinations of its implementation in real-world projects, and analytical frameworks for assessing its effects on organizational performance. These studies deepen our understanding of how ambidexterity functions as an essential capability for organizations to navigate complexities and uncertainties, underscoring the theoretical significance and practical value of ambidexterity in projects.

Liu and Leitner (2012) argue that as projects progress, the emphasis shifts gradually from exploration to exploitation, resulting in reduced uncertainty. Eriksson, Leiringer, and Szentes (2017) explore the concept of ambidexterity in conjunction with co-creation of value, highlighting the benefits of collaboration between customers and suppliers in different project stages. Turner et al. (2014) provide insights into the role of ambidexterity in project delivery and propose a framework to comprehend the intricate interaction of social, organizational, and human capital during project execution. Turkulainen and Ruuska (2022) discuss practices and processes to facilitate alignment and adaptability in various program phases, emphasizing the role of specific organizational units as ambidexterity facilitators. Sergeeva and Ali (2020) investigate the role of Project Management Offices in fostering innovation from the project's front-end to its operational back end.

Sailer (2019) emphasizes the significance of project management methods that combine mechanistic and organic approaches to achieve ambidexterity effectively. Sun et al. (2020) focus on ambidexterity in project-based organizations, highlighting the spatial separation between functional and project units to balance efficiency and flexibility. On a project level, they emphasize the importance of temporal separation between different project life cycle stages to achieve ambidexterity. Zerjav, Edkins and Davies (2018) suggest that routine-based capabilities can be developed not only to ensure stability but also to provide a space for exploration when conditions change. Eriksson and Szentes (2017) stress the significance of sequential ambidexterity and innovation in early project stages, gradually shifting focus to efficient production based on prior experience and knowledge in later stages. Liu, Wang, and Sheng (2012) utilize a four-phase lifecycle model to illustrate how ambidextrous management is enabled by the temporal segregation of exploration and exploitation, as well as their integration during each project stage.

One area with still incipient interest, which this thesis aims to expand, is how contracting relates to project ambidexterity. Eriksson (2013) argues that contractual aspects, such as partner selection based on multiple criteria, incentive-based payment, and collaborative tools, positively influence ambidexterity in projects. The author proposes adopting contracting as a framework to facilitate both exploration and exploitation at the project level effectively. Similarly, Eriksson and Szentes (2017) suggest that early contractor involvement enhances ambidexterity, while contracting strategies that separate explorative design from exploitative production may impede innovation. Davies, Dodgson, and Gann (2016) demonstrate that dynamic capabilities supporting ambidexterity can be integrated into the contracting strategy of megaprojects. They discuss a multiparty contract that employs partnering principles to foster flexibility and innovation. Sergeeva and Ali (2020) explore how Project Management Offices (PMOs) can promote ambidexterity through collaborative contracting approaches that engage contractors early in the process. Recently, Liu et al. (2022) conducted an analysis of the Design-Build general contracting utilized for the Hong Kong-Zhuhai-Macao Bridge megaproject, where the client embraced a partnership philosophy with many different firms.

2.4. Temporal and structural ambidexterity

Drawing on the contributions of organizational theory, project management studies have highlighted the main approaches to achieve ambidexterity in project contexts. One way is for organizations to establish distinct structures or units to handle exploration and exploitation in projects separately. This separation allows each sub-project type to follow the methodologies and practices that best suit its specific requirements without undue interference from the other. Another approach involves allocating specific timeframes or phases within a megaproject's lifecycle for exploration and exploitation. By setting dedicated periods for innovation and stability, the project can benefit from both elements without compromising either. Lastly, organizations can adapt their project management practices, resource allocation, and risk management strategies to suit the context of each project's moment.

2.4.1. Temporal separation

The temporal dimension of ambidexterity involves focusing on exploitation and exploration one task at a time (Tushman & O'Reilly, 1996; Uotila, 2018). According to Liu and Leitner (2012), temporal separation between exploration and exploitation is a natural occurrence in projects, because of the focus on lifecycle management. The front-end of projects offers great opportunities for exploration (Davies et al., 2014; Sergeeva and Ali, 2020). This stage allows for some exploration of innovations before gradually transitioning to exploitation. Studies of new product development projects have depicted this innovation process as a development funnel (Hauser, Tellis & Griffin, 2006; Wheelwright & Clark, 1992; von Zedtwitz, Friesike, & Gassmann, 2014), with the front-end corresponding to the 'fuzzy' stages of that funnel, when all sorts of theoretical concepts are explored (Edkins et al., 2013; Koen et al., 2001; Khurana & Rosenthal, 1998).

However, the project's lifecycle is a spectrum where the value of incorporating new ideas gradually decreases (Williams, Sunnevag and Samset, 2009). The advantages of exploration are higher in the earliest stages of the front-end, while some innovations may not be viable due to late-stage implementation (Worsnop, Miraglia, and Davies, 2014). After an initial exploration phase, megaprojects must exploit existing competencies to reduce risks and prepare for execution (Merrow, 2011). This is explained because of the need to define the project before a final investment decision is made. After an initial phase of exploration, the project organization must exploit existing competencies to reduce risks, to replicate designs and prepare for execution.

2.4.2. Structural separation

Another path to ambidexterity is to structurally separate the tasks of exploration and exploitation. Some organizational units become responsible for exploiting and others for exploring (Benner & Tushman, 2003). In the context of projects, it is believed that the demand for horizontal coordination breaks down the benefits of structural ambidexterity because separate organizational units cannot effectively work simultaneously with exploitation and exploration (Liu and Leitner, 2012). However, one thing that the literature does not mention is the potential for achieving ambidexterity through collaboration.

In a context of complex inter-organizational settings, where multiple organizations participate in the project, there is a large potential for the project owners to learn from contractors and drawn on their experience from other projects. While from the owners´ perspective this is exploring, from the contractor's perspective there is a high degree of exploitation. This could be understood as an equivalent to what the literature generally refers to as structural separation of ambidextrous tasks.

Studies on project capabilities suggest that megaprojects are composed of project-based firms whose line of business is to provide repeatable solutions by recycling learning from one project to the next (Davies and Hobday, 2005; Davies, Gann and Douglas, 2009). Replication and refinement of learning is how these project-based firms exploit their own competencies to improve the performance of project activities (Davies et al., 2011). Hence, when collaboration is organized during the early stages of the front-end, the organizational units from owners are exploring options while the front-end units from suppliers are exploiting economies of repetition, using routines and existing knowledge to create customized proposals (Davies and Hobday, 2005). Hence, although it is argued that structural separation does not lead to ambidexterity in the project team context (Liu and Leitner, 2012), the dynamics of collaboration provide opportunities for ambidextrous search.

2.4.3. Contextual separation

During the life of the project, individuals can be encouraged to make their own judgments as to how best divide their time between conflicting demands of exploration and exploitation (Sun et al., 2020). Turner et al. (2014) considers ambidexterity in this context as the intelligent balancing of exploitation and exploration. Future events in a complex project are not fully predictable, so appropriate responses to unfolding situations and context-specific problem-solving are necessary. Hence, although there is an important period for exploration in the early phases of the front-end, organizations remain flexible to explore new solutions to unforeseen circumstances and emerging opportunities (Eriksson, Leiringer, and Szentes, 2017; Gann, Davies and Dodgson, 2017).

2.5. A lifecycle approach

To analyze contracting innovations and their impact on ambidexterity (exploration and exploitation), it is important to consider the lifecycle of the megaproject because what dictates the leeway for contractors to propose and adopt innovations is when they are involved in a megaproject and for how long. The lifecycle is a sequential model that represents the transition of the project organization through definition phases, and the different tasks and deliverables they must accomplish in each of those phases (Morris, 2013; Winch, 2010). Definition phases are generally intercalated by stage- or decision-gates. At each stage-gate, the project organization assess if the goals of the previous phase were achieved and make a formal decision to either go back, stop, or go forward with the next phase (Merrow, 2011). Definition phases and stage-gate controls are ubiquitous features of project management systems of mega and major infrastructure projects (Addyman, Pryke, and Davies, 2020). A rough schematic of these phases can be summarized as:

a) A front-end phase with sub-phases to appraise the business opportunity; assess the technical and economic feasibility of the project; define a concept; mature design for project approval.

b) A development phase with sub-phases to perform detailed engineering; procurement; construction; installing and commissioning; handing over to operations.

c) An operations and maintenance phase, which is self-explanatory and can take many decades after delivery.

In this thesis, I discuss contracting and innovation using the lifecycle of megaprojects as a framework. From that perspective, innovations in contracting have to do with the integration of several lifecycle phases. Traditionally, contractors would answer a call for bids, exchange promises on rates and schedules, and this would form the basis for the clients to decide if they wanted to commit with investing in execution or rethink their strategy. From the 1990s onwards, new forms of contracting were sought to involve contractors into the front-end, so they could support owners in design, which is often referred to as early contractor involvement, or ECI (Mosey, 2009; Rahman & Alhassan, 2012; Song, Mohamed and AbouRizk, 2009).

However, within the universe of ECI practices, numerous contracting strategies can be developed, depending on the perception of project organizations over the value of (1) collaborating on an exclusive basis with a contractor or having multiple design partners, (2) splitting the selection process into rounds of collaboration or having just one contract relation from design to execution; and, even more importantly, (3) when to involve contractors, considering all the sub-phases of the front-end mentioned above. The combination of these elements is what constitutes the changes in contracting seen in some industries (Merrow, 2022).

3. Empirical context

3.1. Offshore oil and gas industry and megaprojects

Offshore oil and gas is a dynamic global industry which has been traditionally organized around multibillion-dollar megaprojects (Merrow, 2011; Stinchcombe and Heimer, 1985). The costs of offshore megaprojects derive from the mobilization of seismic vessels and drilling rigs, as well as the construction and installation of a large production infrastructure on site, which has to operate far away from shore with little downtime as possible.

Offshore discoveries need to be larger to be economical. There are economies of scale gained by having costly facilities on site to access one large discovery or multiple ones simultaneously, spreading investments across a long operational life. However, with innovations like floating platforms, subsea technology, flexible risers and horizontal drilling, the industry developed capabilities to exploit smaller fields as well.

These new technologies also made it possible for the industry to move into deeper waters and other difficult environments. From the 1990s and into the 2000s this led to a stream of even more complex megaprojects. At this time, ultra-deep fields in US Gulf of Mexico, Brazil and West Africa, were the largest developments. Other regions followed the same trend. In his book on megaprojects, Edward Merrow (2011) argued that the depletion of easily accessible fields would continue this trend, making new projects even larger and more complex. The scale of floating platforms and complementary systems is such that even small and medium sized projects for offshore standards will still be defined as megaprojects.

Now, in the 2020s, the offshore industry looks back to 50 years where megaprojects have been the dominant features of its activities. The problems surrounding offshore oil and gas are also the same ones found in the broader megaproject environment, the most recurrent ones being cost overruns and delays. The majority of megaprojects in offshore oil and gas can be classified as failures and suffer from operability problems (Merrow, 2011). Evidence of cost overruns in offshore is further supported by industry reports (EY, 2014; Oil & Gas Authority, 2017) and academic research (Olaniran et al., 2015).

3.2. Scope of megaprojects in the offshore industry

Offshore projects differ significantly, depending on field characteristics. When oil or gas reserves are big, operators will likely develop a production infrastructure on site. The most visible part of an offshore infrastructure is a platform, which contains facilities and equipment on a surface deck to perform tasks like processing, monitoring and controlling production, drilling, accessing the wells, housing the crew and storing oil.

Offshore platforms can be fixed to the seabed by substructures with tubular steel or reinforced concrete; or they can float like ships, with their hulls moored to the seabed. The choice of what tasks should be performed on site and what type of substructure is best for a given field are made according to features like water depth, distance from shore or other installations, the proximity of existing export pipelines, weather and sea characteristics, etc.

One less visible part of an offshore infrastructure is the system of equipment in the seabed that operators install with the purpose of monitoring and controlling what goes in to and out from the wells. It is not always necessary for operators to have subsea systems, but it has become a standard application. A pipeline network transports production fluids from the subsea production system to the host facility and also carries hydraulic fluids, chemicals and electric power from the surface to the subsea production systems. Subsea production systems can be spread across kilometers away from each other and the platform, thus enabling operators to cover a wide area.

Some reserves are not large enough for a standalone platform to be economical. In that case, operators will investigate the possibility of connecting the discovered field to one or multiple platforms that are already operating nearby. In mature areas, there are numerous platforms in place that can be used to host output from smaller fields. Projects that don’t use standalone platforms are called tiebacks.

There are two types of tiebacks. One is to use the subsea production system and connect the reservoir to the host platforms through subsea pipelines. The other is to place the equipment on slim facilities on the surface, like a much smaller fixed platform, which doesn´t perform as many tasks. The first type of concept is called a subsea development (or a subsea tieback), and the second one is an unmanned wellhead platform. Is also extremely frequent for operators to increase production output of their fields in phases, creating a standalone facility first, and then adding tiebacks in subsequent phases.

3.3. Contracting and innovation in the offshore industry

There are many sectors where the unique and discontinuous nature of demand for megaprojects makes it hard for project owners to implement new ideas. Oil companies, on the other hand, are serial clients. They have a steady demand for megaprojects, which they undertake in collaboration with a well-established ecosystem of suppliers. This put oil companies in a good position for introducing innovations in contracting, which are later disseminated to other project-based sectors.

One innovation of particular importance was the alliances and partnerships with suppliers in the North Sea (Barlow, 2000; Green, 1995; Green and Keogh, 2000; Halman and Braks, 1999). At the turn of the 1990s, there was a general acknowledgment that the easily accessible fields, with bigger economical margins, were already being explored, and that future projects would comprise one or many of the following characteristics: smaller reservoirs, deeper waters, distant from shore or existing infrastructure, in technically complex areas, and new markets (Moksnes et al., 1995; Inderberg & Lunde, 1994; Gardiner & Monroe, 1994; Moum & Laskemoen, 1993). Adding to this was the fact that oil prices never recovered from the plummeting in 1986, further increasing the pressure to reduce development costs.

In line with concerns about the competitiveness of the North Sea, cost-reduction programs were established to reboot investment activity, containing policy proposals and recommended practices for the industry. Among them was the implementation of alliances. The concept covered a wide spectrum of business relationships that moved away from lowest-purchase price bidding towards performance-based incentive contracts, although the contract language was just a part of it. The real driver for oil companies was to make better use of the resources residing outside their organization: technologies, staff, assets and experience of their suppliers. The contracts were supposed to reflect the new roles that were being assumed by them, coupling incentives for project participants to maximize the application of technical and commercial solutions.

A well-known case of alliances was the development of marginal fields in the UK sector of the North Sea (Littlewoord, 1995). In particular, the pilot projects by BP, which became case studies for alliances worldwide, namely Hyde, Harding and, especially, the Andrew field, the most famous of all (see vignettes about the Andrew field in Barrow [2000, p. 980], Morris [2013, p. 79], and Miller & Lessard [2000, p. 66]).

Simultaneously, in the Norwegian sector of the North Sea, projects were being developed under a similar framework for collaboration (Moum & Laskemoen, 1993). However, it was the Norne field that represented a groundbreaking shift towards integrated teams and optimal use of supplier's competence (Vold, 1995). The pattern among all was similar: contractors were to assume prime responsibility for the design and execution of various elements of the field facilities, with involvement of operators reduced down to a small core management team.

The alliance principles were disseminated across the entire engineering sector. One influential work in the British construction industry is the report Rethinking Construction, from 1998, which credited partnering and alliancing as powerful tools to deliver performance improvements (Egan, 1998; Murray & Langford, 2003). Its chairman, John Egan, served as BAA's chief executive, and he planted the seeds for what came to be one of the most popular successful partnering agreements in the megaproject literature, for the construction of Heathrow's airport Terminal 5.

3.4. The Norwegian offshore industry

It's been long since Norway had a continuous stream of large and very profitable fields being discovered. They have become rarer, although there are still outliers like Johan Sverdrup, a field discovered in 2010 which started production in 2019. Its recoverable reserves are estimated to be much larger than any other field discovered in this decade. However, despite being a declining offshore market, oil and gas still remains Norway's biggest export commodities, and the Norwegian oil and gas supply chain is the second-largest industry in terms of turnover (Norsk Petroleum, 2019). It goes to show the significance of offshore oil and gas for the country.

Figure 1: Total Investments in the Norwegian Continental Shelf (Norwegian Petroleum Directorate, 2020)

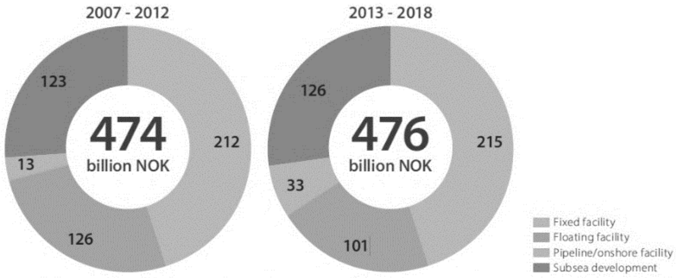


Figure 5 Distribution of PDO cost estimates by development concept and period. Planned investment for projects in 2007-12 totalled NOK 474 billion in 2019 value. The overall cost estimate for 2013-18 was NOK 476 billion in 2019 value.

Since 2007, almost 100 bi NOK were invested in the Norwegian Continental Shelf (NCS), according to the Norwegian Petroleum Directorate. During this period, there were 38 new subsea developments, 7 new floating platforms and 14 new fixed platforms. Tieback projects have far surpassed others as the concept of choice, given that new discoveries are generally smaller, and Norway has a well-established offshore infrastructure to support production without the need for building large new facilities. The majority of oil finds being developed since 2007 had less than 15 million standard cubic meters of oil equivalent (scm oe) and their cost will range from NOK 3 bi and NOK 10 bi, with an average of NOK 6 bi.

In terms of performance, Norwegian offshore projects are doing well, comparatively. Every year, the Ministry of Petroleum and Energy (MPE) presents a document for the Storting (parliament), reporting the status of ongoing energy projects. It includes the initial cost estimates with the updated ones, as the projects progress, thus providing official data on cost overruns. These documents, called Prop 1 S, date back from the early 00s. They provide a good overview of project performance in the Norwegian Continental Shelf.

Of a total of 66 projects approved during 2007-2018, only 11 (17%) had cost overruns above 20%, which is considered to be an acceptable uncertainty range. All projects combined have an average 8% increase from initial estimates, totaling NOK 75 billion. The vast majority of projects with overruns date prior to 2013. Post-2013 had a cost reduction of 8% on average.

According to an analysis made by the Norwegian Petroleum Directorate (NPD), called Project Execution on the Norwegian Continental Shelf (2020), two factors account for that. New discoveries in the NCS are increasingly marginal, which means that there needs to be a stronger focus on cost efficiency so that projects are sanctioned in a lower oil price environment, with the strong competition of shale oil and renewable energies. Also, the NPD had increased its follow-up of projects in the planning phase since 2013, adding more formalized feedback to licensees at appraisal and select phases.

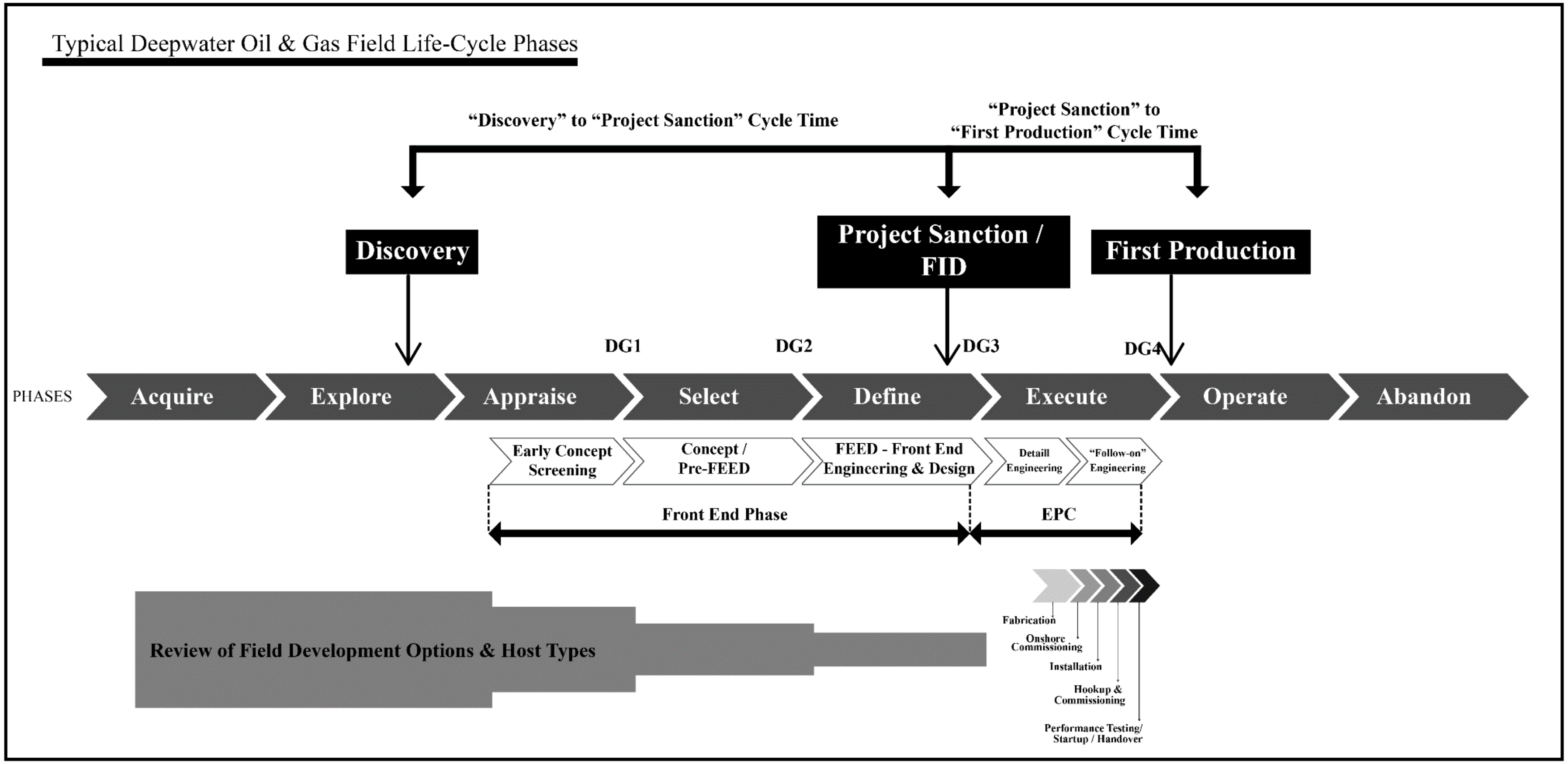
Improvements in the overall performance of Norwegian projects is credited to changes to form of contracts and collaboration between operators and contractors. In the Norwegian Petroleum Directorate (2020) report, they comment: "The significance of ensuring continuity of main contractor(s) from FEED [a type of basic engineering contract] before the PDO to detail design afterwards has been highlighted by several development operators in meetings with the NPD. This helps to ensure that suppliers are familiar with the project when detail design starts and have ownership of the chosen solutions" (p. 30).

The importance of contractors in achieving cost efficient solutions is backed up by another report, wrote on behalf of the Norwegian Energy Partners, NORWEP (Henriksen, 2019). Emphasis is placed on joint work between contractors and operators during planning to trim out excess requirements.

3.5. A lifecycle perspective to offshore megaprojects

Developing an offshore field is a lengthy process, which can take up between 5 to 10 years from when the field is declared commercial to production start-up. The front-end starts when a discovery is made. Operators will conduct an appraisal program to assess all relevant information about the reservoir and confirm if the discovery is commercially attractive. Concurrently, they will start narrowing down the development options and host types. First, operators and their partners in the project explore a list of concept alternatives that fit the particular field. Then, they go through an organized convergence process, knocking out options that are less attractive, retaining the ones that are more, and carrying them on to next phases, until all are confident to execute the concept that was chosen.

Figure 2: Typical offshore field life-cycle phases



Each stage has a corresponding level of definition and a scope of work, followed by a formal decision gate (DG), in which all concessionaire partners in the field make a formal decision whether they want to advance to the other phase or stop the project.

The front-end in offshore projects is generally structured with 3 decision gates. The purpose of the first phase is to confirm the feasibility of the field (DG1), the second one to select a concept (DG2), and the third one to develop this concept for a formal investment decision (DG3). The structure of the front-end is a legacy of the late 1980s and early 1990s, when operators begun to adopt the front-end loading methodology, or FEL (Gass, 1999; McClung, Brooker and Laine, 1996; Steffensen and Karstadt, 1996; Woodruff, 1997). Most companies nowadays have adopted a stage-gate project management process for megaprojects.

FEL is a structured approach to investing resources in the planning phase. It places value on experience early in the project development process, to avoid interface conflicts between design groups, and weaknesses in the overall design (Knowles, Selwa and Bankes, 1999). It has been promoted by the consultancy firm Independent Project Analysis, which has been working with operators since the 1980s. Its leader, Edward Merrow (2011), has been a strong advocate for the adoption of FEL to support megaproject planning.

4. Methodology

This thesis results from a multiple-case study with suppliers and operators in the Norwegian offshore oil and gas industry. Interviews were made with 72 informants that are directly connected to offshore projects. Data collection was focused on the engineering and construction segment. It excludes other very important firms that provide seismic or drilling equipment/services.

My work as a PhD candidate was part of the Globoil project, which had as its primary goal to study transformations in the Norwegian offshore oil and gas sector, using a set of broad research questions and work packages (Globoil, 2017). In the first months, a series of meetings were made to divide responsibilities in the program. I took responsibility with following-up on a topic explored for the first time in another research project about offshore oil and gas led by TIK, called SIVAC, or Supplier Industry and Value Creation (Thune, Engen and Wicken, 2019). The topic was the emergence of FEED contracts [a study for basic engineering] in offshore oil and gas as evidence of how new forms of contracts were being developed by industry actors to collaborate under uncertainty. My work was to pick up where SIVAC had left but using new data on the collaboration between operators and suppliers and the adoption of FEED contracts.

4.1. Research project context

In 2018, researchers from the University of Oslo launched the Globoil project in collaboration with other universities to study transformations in the Norwegian offshore oil and gas industry (Globoil, 2017). Globoil was effectively a spin-off from SIVAC, another research project on offshore oil and gas within the same university a few years earlier (Thune, Engen and Wicken, 2019). Many researchers that worked in the SIVAC project went on to collaborate in the Globoil project.

In SIVAC's book closing remarks, scholars Charles Sabel and Gary Herrigel (2019) compared the development of new contracts in offshore oil and gas with that of the pharmaceutical and automobile industries. For Sabel and Herrigel (2019) the reliance on external actors to innovate and the pervasive uncertainty across all industries were two factors enabling the creation of new forms of contracts, which are more open-ended in terms of their outcomes and have an explicit aim to encourage collaboration. This analytical framework was very influential in the beginning and served as a starting point for the works in the Globoil project.

One gap in the SIVAC book was the absence of a project level analysis. Contracting innovation in project-based sectors is better understood when considering definition phases, stage-gate controls, site conditions, technology parameters, stakeholder involvement, to name a few. Moreover, unlike long-term operational tasks where suppliers provide mass components on a regular basis, in most project-based sectors the relationship with suppliers is dismantled after a one-off asset is delivered, limiting their ability to develop continuous improvement practices.

My research work aimed at developing Sabel and Herrigel's (2019) argument further, by exploring how the need for innovation and collaboration define contracting strategies in a project context, more specifically, megaprojects, where uncertainty and complexity are a dominant condition. As discussed in previous sections, megaproject organizations have adopted new forms of contracts to encourage collaboration with contractors. More prominent experimentations with contracting were the build-own-operate model and partnering agreements. At the time of my research, other alternatives were being developed such as front-end studies and two-stage tendering. Those were the object of my research.

4.2. Primary data collection

The process of primary data collection is best described in four phases. In my first year, until the summer of 2019, my main objective was to learn about the offshore industry: the work packages, key suppliers, technologies and different concept solutions. For that purpose, many interviews were made without focus on any specific subject. The objective was to have open-ended discussions and learn the development of collaborative relations between oil companies and suppliers.

The first 20 respondents in this first phase of research can be roughly divided in three clusters: TechnipFMC snowball interviews; smaller suppliers developing innovative products; and specific projects by smaller operators. First, I had a breakthrough with an engineer from TechnipFMC, one of the largest firms in the industry, who set up a program for us. Many topics were discussed with several respondents, such as product innovation, relationship with sub-suppliers, and FEED studies. Second, I spoke with four different smaller suppliers to learn the story of their innovative products, from idea to commercialization. Lastly, I spoke with managers from Spirit and Neptune about the contracting strategies for their offshore projects, respectively, Oda and Fenja.

A second phase of research started in June 2019, when the Globoil project had the first group interviews, organized by Helge Ryggvik and me. As a result, the three interviews from 17/06/2019 to 18/06/2019 were the only ones in my sample I was only an observer. The second phase of data collection and analysis was very much focused on contracting strategies, like FEED studies and alliances. There was also two interviews with Lundin representatives about (1) the Edvard Grieg project and (2) the contracting strategies used by the oil company.

From the second to the third phase there is a 6-month gap approximately. It coincides with the Covid-19 pandemic, which made it impossible to have physical interviews, our main form of data collection. It was also an interim period where I had done enough research to reflect on how I wanted to organize my findings in different papers and also what respondents I should approach next. By that time, I was already drawn to the megaproject literature, so I had a clearer idea on how the experience of offshore firms in Norway could be useful to discuss problems related to megaprojects.

I decided to write three papers. The first two would be about the emergence of front-end studies as a contracting innovation in offshore megaprojects, including FEED contracts. The third one would be a single case study on the megaproject Johan Sverdrup I. The reason for that single case study was that Johan Sverdrup had been delivered on time and below budget, which it is identified by the megaproject literature as a key problem. The focus on the third phase of research was to talk with people that had important roles in Johan Sverdrup, and, when possible, have 15 or 20 minutes to also confirm findings about front-end studies. Only the interview with an Wintershall respondent did not cover the Johan Sverdrup megaproject in the third phase.

The fourth phase was mostly about confirmation of the main findings. The interviews with Sevan Marine and the last two ones with respondents from Aker Solutions and Aibel were important to confirm some details of front-end studies. There was one interview with three auditors from the Petroleum Safety Authority, to understand performance problems in a project called Johan Castberg, and compare it with Johan Sverdrup. Another interview worth mentioning was with the project director for Johan Sverdrup who was acting at the time of our interview as Aker Solutions' CEO. There were also four interviews with AkerBP to discuss their alliance portfolio and collaboration with suppliers in many offshore projects in Norway.

In total, 67 semi-structured interviews were made with 72 informants. The interviews lasted from 90 to 120 minutes. All interviews were recorded and had parts transcribed. The respondents were mainly identified online, by searching for specific roles and names of firms.

Most of the respondents had LinkedIn pages, with detailed description of their responsibilities. They were approached by e-mail. In other cases, respondents were suggested by others, in a snowball approach.

Table 1: Interviews ordered by dates and phases

Information about participants			**Interview Dates**	
Code	**Firm**	**Position**	**1st**	**2nd**
#1	TechnipFMC	Manager Subsea Controls Technology Development	20/12/2018	
#2	TechnipFMC	Manager Subsea Controls Products Engineering	20/12/2018	12/03/2019
#3	TechnipFMC	Manager C&A Control System & IWOCS Engineering	20/12/2018	
#4	DNV-GL	Head of Section, Subsea Technology	03/01/2019	
#5	DNV-GL	Senior Principal Engineer, Subsea Technology	03/01/2019	22/03/2019
#6	Neptune Energy	EPCI Manager/Company Rep	15/01/2019	
#7	Neptune Energy	Contract Manager	15/01/2019	
#8	Neptune Energy	Project Manager	15/01/2019	
#9	NOV Seabox	Managing Director	15/01/2019	21/02/2019
#10	NOV Seabox	Manager Operations	15/01/2019	
#11	Spirit Energy	Senior Project Manager Oda	15/01/2019	
#12	Trelleborg	BG Director	06/02/2019	
#13	Cubility	VP Technology	14/02/2019	
#14	FSubsea	Founder and CEO	14/02/2019	

Information about participants			**Interview Dates**	
Code	**Firm**	**Position**	**1st**	**2nd**
#15	TechnipFMC	Manager, Sourcing C&A, New Products	12/03/2019	
#16	TechnipFMC	NPD & Innovation Manager	14/03/2019	
#17	TechnipFMC	Chief Product Developer	14/03/2019	
#18	TechnipFMC	Manager Integrated EPCI FEED & Eng. Management	20/03/2019	
#19	TechnipFMC	Chief Product Developer	20/03/2019	
#20	ABB	Managing Director, Oil, Gas and Chemicals	03/06/2019	
		Phase II		
#21	Aker Solutions	Project Director	17/06/2019	
#22	Aker Solutions	Head of Products	17/06/2019	
#23	TechnipFMC	Manager, Feasibility & Concepts, Front End Norway & Russia	18/06/2019	
#24	Subsea 7	Global Integrated Field Development Manager	21/06/2019	
#25	Subsea 7	Contracts & Supply Chain Director, Norway	21/06/2019	
#26	Subsea 7	Subcontracts Manager	21/06/2019	
#27	Subsea 7	Vice President – Strategy, Technology, R&D	21/06/2019	
#28	Aker Solutions	Head of Global Category Management	06/08/2019	

Information about participants			Interview Dates	
Code	**Firm**	**Position**	**1st**	**2nd**
#29	Sevan Marine	Head of Business Development	15/08/2019	
#30	Kvaerner	SVP Corporate Support & General Counsel	18/09/2019	
#31	Kvaerner	SVP Engineering EPCI	19/12/2019	
#32	Lundin	Field Development Director	10/06/2020	
#33	Lundin	Project Manager	03/09/2020	
#34	Equinor	VP Project Management & Control	12/11/2020	
		Phase III		
#35	Aibel	Project Director	12/04/2021	
#36	Equinor	Project Manager for Drilling Platform	13/04/2021	
#37	Lundin	Process Engineer (involved in concept phase)	13/04/2021	
#38	Aker Solutions	Project Director	14/04/2021	
#39	Equinor	Project Director	16/04/2021	20/08/2021
#40	Equinor	Head of Digitalization	20/04/2021	
#41	KBR	Project Director for Living Quarter and Utility Platform	22/04/2021	
#42	Kvaerner	Project Director for Living Quarter and Utility Platform	22/04/2021	29/04/2021

Information about participants			Interview Dates	
Code	Firm	Position	1st	2nd
#43	Leirvik	Project Manager for Accommodation Module	22/04/2021	
#44	Aker Solutions	Engineering Manager EPCI	23/04/2021	
#45	Aker Solutions	Front-End Manager	23/04/2021	
#46	Equinor	Project Manager for Jackets, Installation and Commissioning	23/04/2021	
#47	Equinor	Vice President Field Center Engineering & Procurement	26/04/2021	
#48	IKM	Project Manager for Subsea and Pipeline Engineering	27/04/2021	
#49	IKM	Project Manager for Subsea and Pipeline Engineering	27/04/2021	
#50	Wintershall	Head of Facilities	27/04/2021	
#51	Allseas	Senior Project Manager – Topside Installations	28/04/2021	
#52	Equinor	Project Manager for Living Quarters and Utility Platform	29/04/2021	
#53	Equinor	Concept Selection Manager	30/04/2021	
#54	Kongsberg	Senior Project Manager for Safety & Automation Systems	11/05/2021	
#55	Equinor & OMV	Concept and Facilities Manager	14/05/2021	
#56	ABB	Project Manager for Delivery Contract	20/05/2021	
#57	ABB	Engineering Manager FEED	20/05/2021	
#58	Kvaerner	Specialist Engineer Steel Jackets	20/05/2021	

Information about participants			Interview Dates	
Code	Firm	Position	1st	2nd
		Phase IV		
#59	Aibel	Construction Manager Haugesund Yard	09/07/2021	
#60	Aker BP	VP Operations & Asset Development	05/08/2021	
#61	Aker BP	PM Ærfugl / PRO Skarv & Ivar Aasen	11/08/2021	
#62	Aker BP	Alliance Manager, Fixed Facilities Alliance	13/08/2021	
#63	Aker BP	SVP Projects	23/08/2021	
#64	Aker Solutions	President & Chief Executive Officer	24/08/2021	
#65	Sevan Marine	Lead, Hull and Structure	16/09/2021	
#66	Wintershall	Head of Facilities	20/09/2021	27/09/2021
#67	Petroleum Safety Authority	Member of Investigation Team	21/09/2021	
#68	Petroleum Safety Authority	Member of Investigation Team	21/09/2021	
#69	Petroleum Safety Authority	Investigation Leader	21/09/2021	
#70	Sevan Marine	Business Development Manager	23/09/2021	
#71	Aker Solutions	Senior Project Manager - Front End Studies	27/09/2021	
#72	Aibel	Manager Field Development, Concepts and Studies	15/11/2021	

4.3. Secondary data collection

A lot of secondary data was collected in parallel with the interviews during the three and a half years of research. I created a database with all offshore projects developed in Norway, by merging publicly available information from the Norwegian government. Every year, the Ministry of Petroleum and Energy (MPE) presents a document for the Storting (parliament), reporting the status of all ongoing energy projects, with the updated costs. These documents, called Prop 1 S, date back to 2000.

Once data from Prop 1 S documents was consolidated, I studied most projects individually, using three sources. The first source was a virtual library of technical literature on offshore oil and gas projects, including peer-reviewed papers presented at the most prestigious conference in the industry, the Offshore Technology Conference. The second source was a specialized media outlet that covers offshore projects worldwide, called Upstream Online. The third source was a database on global offshore projects provided by Rystad, an oil and gas consultancy firm, which the Globoil project made a subscription for all its researchers.

Below is a table with information about projects in Norway. Based on this, I would search online about contracts and suppliers, using mostly OnePetro or Upstream Online.

Table 2: Dataset with offshore projects in Norway

PDO Year	**Field Name**	**Original Estimate NOK billions**	**Last Estimate NOK billions**	**Concept (simplified)**
2019	johan sverdrup ii	43063	43665	Subsea Tieback + Process Platform
2019	solveig	6493	6493	Subsea Tieback
2019	duva	5492	5492	Subsea Tieback
2019	gullfaks shetland/lista fase 2	2230	2230	New production wells + new injection wells
2018	johan castberg	49453	49037	FPSO w/ Subsea Templates
2018	snorre expansion project (sep)	20182	19657	Subsea Tieback
2018	fenja	10689	10420	Subsea Tieback
2018	nova	9828	9767	Subsea Tieback
2018	ærfugl	8659	7942	Subsea Tieback
2018	yme new development	8622	9254	Jack-up Platform w/ Subsea Templates
2018	troll fase 3 step 1	7801	7573	Subsea Tieback + New processing module
2018	valhall flanke vest	5715	5613	Unmanned Wellhead Platform
2018	skogul	1557	1763	Subsea Tieback

PDO Year	Field Name	Original Estimate NOK billions	Last Estimate NOK billions	Concept (simplified)
2017	njord future	15799	20292	Modifications in existing platform
2017	dvalin	10941	10737	Subsea Tieback
2017	trestakk	5817	5057	Subsea Tieback
2017	oda	5766	5266	Subsea Tieback
2017	bauge	4112	3691	Subsea Tieback
2017	utgard	3391	2853	Subsea Tieback
2017	ekofisk 2/4 vc	2370	1781	Subsea template for water injection
2017	byrding	1001	1083	2 new production wells (drilled from Fram-H)
2016	oseberg vestflanken 2	8585	6967	Unmanned Wellhead Platform + New production wells
2015	johan sverdrup i	129667	98230	Field Center w/ 4 platforms
2015	maria	16540	12632	Subsea Tieback
2015	rutil i gullfaks rimfaksdalen	5033	3822	Subsea Tieback
2014	flyndre	3733	4510	Subsea Tieback
2014	utsirahøgda gassrøyrleidning	1476	1247	Gas Pipeline System
2013	aasta hansteen	35359	37757	Spar w/ Subsea Templates
2013	gina krog	32186	32343	Fixed Platform (processing and living quarters)

PDO Year	Field Name	Original Estimate NOK billions	Last Estimate NOK billions	Concept (simplified)
2013	ivar aasen	27889	27469	Fixed Platform + Jack-up Rig
2013	oseberg delta 2	7551	7542	Subsea Tieback
2012	martin linge	30363	56094	Fixed Platform + FSO
2012	edvard grieg	23415	25848	Fixed Platform
2012	åsgard [underwater compression]	17248	20758	Subsea Gas Compression Template
2012	skuld	10125	11033	Subsea Tieback
2012	bøyla	5229	5709	Subsea Tieback
2012	svalin	4564	4244	Subsea Tieback
2012	jette	2655	3611	Subsea Tieback
2011	eldfisk 2 [Eldfisk 2/7 S]	39399	40057	Fixed Platform (wellhead and accommodation)
2011	ekofisk sør	28799	27999	Fixed Platform and subsea water injection template
2011	valemon	20045	22298	Fixed Platform (Unmanned)
2011	knarr	12196	14089	FPSO w/ Subsea Templates
2011	visund sør	5808	5371	Subsea Tieback
2011	stjerne [Oseberg Sør Expansion]	5484	4593	Subsea Tieback
2011	hyme	4649	4613	Subsea Tieback

PDO Year	Field Name	Original Estimate NOK billions	Last Estimate NOK billions	Concept (simplified)
2011	vigdis nordøst	4380	4500	Subsea Tieback
2011	brynhild	4449	7745	Subsea Tieback
2011	atla	1394	1525	Subsea Tieback
2010	gudrun	20856	20572	Fixed Platform
2010	marulk	4162	4476	Subsea Tieback
2010	gaupe	2828	2376	Subsea Tieback
2010	trym	2753	3048	Subsea Tieback
2009	goliat	32592	50762	Cylindrical FPSO w/ Subsea Templates
2009	oselvar	4937	5120	Subsea Tieback
2008	morvin	8145	8862	Subsea Tieback
2008	troll b gassinjeksjon	2267	1552	New injection wells
2008	yttergryta	1302	1461	Subsea Tieback
2007	skarv	35914	47117	FPSO w/ Subsea Templates
2007	gjøa	30937	33445	Semisub w/ Subsea Templates
2007	valhall videreutvikling [PH facility]	25041	49620	Fixed Platform
2007	vega	6631	10063	Subsea Tieback

PDO Year	Field Name	Original Estimate NOK billions	Last Estimate NOK billions	Concept (simplified)
2007	yme	4894	14114	Jack-up Platform w/ Subsea Storage (MOPU)
2007	volund	3039	3628	Subsea Tieback
2007	rev	2852	3224	Subsea Tieback
2007	alve	2583	2865	Subsea Tieback
2007	tambar øst	313	340	One new production well (drilled from Tambar)
2006	tyrihans	14875	15172	Subsea Tieback
2005	statfjord [late life]	14496	18476	Modifications in existing platforms
2005	fram øst	3977	5509	Subsea Tieback
2005	skinfaks/rimfaks ior	3626	4578	Subsea Tieback
2005	vilje	2216	2743	Subsea Tieback
2005	volve	2092	3061	Jack-up Platform
2005	oseberg delta	1920	2406	Subsea Tieback
2005	tordis ior	1873	2226	Subsea template for water separation and injection
2005	blane	1807	3450	Subsea Tieback
2005	ringhorne øst	1028	1080	4 new production wells (drilled from Ringhorne)
2005	enoch	171	250	Subsea Tieback

PDO Year	Field Name	Original Estimate NOK billions	Last Estimate NOK billions	Concept (simplified)
2005	tampen link	1588	2217	Gas Pipeline System
2005	njord gasseksport	1115	1291	Gas Pipeline System
2004	ormen lange	72582	107127	Subsea to onshore terminal
2004	alvheim	8661	17252	FPSO w/ Subsea Templates
2004	urd	3544	3732	Subsea Tieback
2003	ekofisk vekst [2/4 M]	8422	10245	Wellhead and Process Platform
2003	oseberg vestflanken	2242	2508	Subsea Tieback
2003	oseberg sør j-struktur	1496	1848	Subsea Tieback
2002	snøhvit	43846	64520	Subsea to onshore terminal
2002	vigdis extention	2807	2549	Subsea Tieback
2002	skirne	1872	2102	Subsea Tieback
2002	visund gasseksport	2753	2643	Pipeline to export Gas
2001	kristin	17362	21375	Semisub w/ Subsea Templates
2001	fram vest	4571	3621	Subsea Tieback
2001	valhall flanke	4453	5003	2 Wellhead Platforms
2001	mikkel	2666	2093	Subsea Tieback

PDO Year	**Field Name**	**Original Estimate NOK billions**	**Last Estimate NOK billions**	**Concept (simplified)**
2001	sigyn	2138	2057	Subsea Tieback
2001	vale	660	791	Subsea Tieback
2000	grane	17099	15866	Fixed Platform (accommodation, drilling and processing)
2000	ringhorne	9555	8819	Wellhead Platform
2000	kvitebjørn	9622	10048	Fixed Platform (accommodation, drilling and processing)
2000	valhall vanninjeksjon	4870	7947	Fixed Platform (Water Injection)
2000	ringhorne jurassic	1400	1443	Modifications + Pipeline
2000	tambar	1 038	1 041	Wellhead Platform

4.4. Research validity

Following Eisenhardt (1989), using multiple data collection methods provides a stronger substantiation of the constructs in case study research. The vast information about Norway's offshore oil and gas projects available in specialized media and conference proceedings guided the interview topics and contextualized the information provided by informants. Moreover, the interviews provided meaning and details that were not found in archival sources.

Contractors or oil companies often have different interests, which can affect the research validity if a disproportionate amount of interviews is made with one type of firm in detriment of the other. Therefore, sampling needed to be wide (many firms) and diversified (many segments). As seen in table 2, I created a representative sample consisting of suppliers and operators with different organization sizes and areas of specialization. The sample includes the four largest EPC (Engineering, Procurement and Construction) contractors for offshore projects, in terms of revenues in Norway: TechnipFMC, Aibel, Subsea 7 and Aker Solutions. All oil companies in the sample have been involved in important projects recently in the Norwegian continental shelf, including Equinor, the largest oil company in the country.

Other measures to increase validity were confirmation interviews on phase III and IV of data collection, peer defriefing and member checking (Robson, 2002). After two and a half years, speaking with 34 respondents, and building a solid knowledge of contracting strategies and adoption of front-end studies, I still conducted many interviews to confirm what had been described to me before. I also presented and discussed my research with others at the Globoil project who could provide helpful criticism. Lastly, I circulated paper drafts and reports among respondents and asked them for comments or corrections. This proved very useful, as the rate of reply was significant. With some respondents I even had validation interviews.

Table 3: Main segment (simplified) and number of respondents from firms in the sample

Main Segment	Company	Number of Respondents
EPC Contractor SPS/SURF	TechnipFMC	9
Operator	Equinor	9
Engineering and EPC contractor SPS	Aker Solutions	8
EPC Contractor Topsides and Steel Jackets	Kvaerner	4
EPC Contractor SURF	Subsea 7	4
Operator	Aker BP	4
Supplier Instrumentation, Automation and Power from Shore Cables	ABB	3
EPC Contractor Topsides	Aibel	3
Engineering Services Hull	Sevan Marine	3
Operator	Lundin	3
Operator	Neptune Energy	3
Engineering Services SURF	IKM	2
Sub-supplier Subsea Equipment	NOV Seabox	2
Operator	Wintershall	2
Sub-supplier Polymer Solutions	Trelleborg	1
Suplier Installation	Allseas	1
Sub-supplier Drilling Equipment	Cubility	1
Sub-supplier Subsea Equipment	FSubsea	1
EPC contractor Topsides	KBR	1
Supplier Instrumentation and Automation	Kongsberg	1
Contractor Accommodation Modules	Leirvik	1
Operator	Spirit Energy	1

4.5. Data analysis

The central research objective in this thesis is understanding how contracting innovations impact joint exploration and exploitation in megaprojects. Addressing this matter imposed several critical considerations for data analysis. Firstly, it required identifying examples of innovations being explored within the offshore industry, thereby providing insight into current technological advancements and trends. Secondly, the task involved identifying specific contracting innovations and connecting them to the methods by which exploration was organized by oil companies. An additional challenge lay in comprehending the impact of these contracting innovations. Here, impact refers to what was made possible to explore in collaboration with contractors, as well as the anticipated benefits. It is a term that encapsulates both the exploratory potential and the advantages arising from these explorations.

Finally, these various strands of investigation were synthesized into four major themes, each offering a unique perspective on the subject matter. These themes were revised and organized to present a comprehensive view of the research question, representing the innovations pursued in the offshore industry, how exploration is organized, why contracting innovations are used, and the benefits or rationale for joint exploration. These four themes encompassed 39 descriptive codes based on participants' responses, capturing the essence of the participants' views, experiences, and insights.

A. What Innovations Are Being Pursued in the Offshore Industry:

The data delineate a series of innovative developments that are shaping the offshore industry. The emergence of electrification and power-from-shore technologies signals an industry-wide shift towards sustainable energy practices. The implementation of pipeline bundle technology and electric trace heat adds momentum to the transformations happening in the subsea segment. Standardization, along with developments in the design of steel structures and new construction methods, underscores efforts to create more efficient practices across the industry. Furthermore, integrated work packages are indicative of a trend towards vertical strategies, combining technologies that were previously provided by different companies under separate contracts. Lastly, the adoption of new floating platform concepts in the Norwegian Continental Shelf over the last decade represents a major development, as it provides oil companies with more alternatives for field development through alternative technologies.

B. How Exploration Is Organized:

Exploration within the offshore industry is characterized by a convergence process, organized in different front-end phases and study types, alluding to a process of increasing design maturity. The participation of multiple suppliers reveals a collaborative model, enabling diverse expertise and perspectives to be integrated into the front-end phase. Contractor continuity suggests a system that harmonizes the need for broad exploration with the imperative for competitive development. The data highlight that competition, whether through FEED or Pre-FEED studies, plays an integral role in fostering innovation.

C. Why Front-End Studies Are Used:

Front-end studies serve as a critical mechanism in the exploration process, as elucidated by the data. They act as a tool to explore various contractors' strengths, competitive advantages, alternative concepts, and novel design solutions. These studies are instrumental in investigating different problems and their relationships to infrastructure, thus providing comprehensive insights into a project's feasibility and challenges. The emphasis on exploring new technologies, whether adapted from other environments or recently developed, signifies an industry that must balance its risk aversion while simultaneously remaining receptive to technological advancements in other contexts. The focus on standardization and market competencies reflects alignment with broader global trends.

D. Benefits or Rationale for Joint Exploration:

The data affirm that joint exploration in the offshore industry is underpinned by several mutually reinforcing objectives. Reduction of costs through various means, time optimization, design simplification, and shared responsibility are evident, reflecting a concerted effort to align the objectives of different stakeholders. The themes articulated through these insights provide a nuanced understanding of the current landscape in the offshore industry, showcasing the pivotal role of innovations in shaping future trajectories and operational excellence.

Figure 3: data analysis

A. What Innovations Are Being Pursued in the Offshore Industry:

- A1. Electrification of Subsea Equipment
- A2. Standardization
- A3. Design of Steel Structures
- A4. Power-from-Shore Technologies
- A5. Pipeline Bundle Technology
- A6. Electric Trace Heating for Pipelines
- A7. Development of New Construction Methods
- A8. Implementation of Integrated Work Packages
- A9. New Platform Concepts

B. How Exploration Is Organized:

- B1. Through Different Front-End Phases
- B2. By Utilizing Various Types of Front-End Studies
- B3. By Increasing Studies in Design Maturity
- B4. By Including Multiple Contractors
- B5. By Ensuring Continuity of Contractors
- B6. Through the Use of Competition
- B6.1. FEED Competition
- B6.2. Pre-FEED Competition

C. Why Contracting Innovations Are Used:

- C1. To Explore Various Contractors' Strengths
- C2. To Explore Contractors' Competitive Advantages
- C3. To Explore Alternative Concepts
- C4. To Explore New Design Solutions
- C5. To Explore Solutions to Different Problems from a Systems Perspective
- C6. To Explore New Technologies
- C6.1. From Different Environments
- C6.2. Developed in Recent Projects
- C7. To Explore Opportunities for Creating Value
- C8. To Explore Materials and Standardization Efforts
- C9. To Explore Market Competencies for Portfolio Decision-Making
- C10. To Explore Contractors' Knowledge of Their Solutions
- C11. To Explore Contractors' Knowledge About Costs
- C12. To Explore Contractors' Creativity
- C13. To Explore Contractors' Ability to Improvise During Execution

D. Benefits or Rationale for Joint Exploration:

- D1. Reduction of Costs
- D2. Simplification of Design
- D3. Sharing Information About Costs
- D4. Reduction of Time
- D5. Optimization of Design
- D6. Increase in Maturity
- D7. Reduction of Tender Costs
- D8. Sharing of Responsibility
- D9. Enhancement of Efficiency

Table 4: Codes and extracts from interviews

Codes	**Extracts**
A. What Innovations Are Being Pursued in the Offshore Industry:	
A1. Electrification of subsea equipment	**Respondent #57:** what I'm seeing more historically is the sense that electrification also changed a bit the role of company and the technology in a more fundamental way because before, of course, you always had electricity on platforms because you need the light and everything and you have digital equipment, et cetera. Then you got the cable from shore, from the same electrical company with the same knowledge which also delivers some of the more detailed equipment, so they become more important. But then you also have the subsea equipment because we have been working both with [name of companies] where they are working with subsea trees and working with innovations where the idea is to electrify as much as possible of the activity subsea.
A2. Standardization	**Respondent #26:** the industry has been talking about standardization for a long time. Everyone wants standardization, and operators have a greater opportunity to do that than contractors. We are in the process of developing ways in which we can standardize, but operators know more and earlier than we do about what fields will be developed, what types of products they're most likely to need and order over the next few years. My point is more about standardization, is that the entire industry is trying to move towards standardization. And in order to have standardization, you need to have some degree of predictability.
A3. Design of Steel Structures	**Respondent #30:** we were on [name of project]. We did three of the [steel] jackets. So, we have lots of technological innovations, actually from the first jacket to the third jacket. But that's then for the steel structures.

	And we have a lot of benchmarking numbers for how we've managed to reduce the cost per kilo of installed jacket, normalized for steel prices and currency effects. So that could be one way to respond to the quest for technological developments. But it's technological developments in a type of construction cost reduction way.
A4. Power-from-Shore Technologies	**Respondent #56:** at that time there was a discussion to connect the Utsira High together [many fields using the same infrastructure], and we looked at that and were involved in the tie ins later on, and we are still working on this to connect the other platforms from [name of project] to the surrounding area. But what was interesting from our side is that we have been some real advocates of power from shore technology and we saw the benefits from this for many years ago. We have technology and development all the time regarding this and we refine both in current and voltage in our system. But that's just how this is normal development of the technology that we are conducting all the time and we need to be cutting edge in, let's say, our design and our application and so on and we have different products and product group in order to fit for its purpose.
A5. Pipeline Bundle Technology	**Respondent #24:** one thing that we see is obviously you're probably aware of our [prefabricated pipeline] bundle technologies. Now we're the only company in the market that is able to design and produce and install bundles. They are a very good fit for some project solutions, but you don't tend to see bundle solutions being proposed by design houses because that automatically ties the project to [name of his company]. So, it's not a generic solution that can then be tendered on the open market.
A6. Electric Trace Heating	**Respondent #6:** we assessed wet insulated pipe. We assessed a single heated pipe. We assessed direct electrical heating. And then we ended up with the best solution for us which was the electric trace heat. Heat trace pipe. It's new and we wanted to have field proven, but we couldn't avoid it. We have lots of details on why we need.
A7. Development of New	**Respondent #42:** we saw that some of the volume work at welding, steel welding, piping welding, some of that, it was cheaper to do either in Poland or in the East Asia. So, we looked at the plant and said that we have to do

Construction Methods	something, but if we're going to get something from the outside, we had the old crane that took about 350 tons. So, we were limited to the sections that we could get from outside to about 350 tons. That was not in a size that it should be to be able to get a volume of low-cost work done outside and get it in here and then make the outfitting and more or less convert from a construction yard to an assembly yard. So, the decision was taken to invest about 300 plus millions in the new crane. So that gave us the opportunity to hand larger pieces and that we could get more from longer distance. So, we converted the yard in a way that we could handle more production from outside and more into an assembly yard. When we did [name of project], we could utilize that. […] If you are already involved in the FEED or pre-FEED you know how your yard is structured. You need to look at the yard as an assembly line in a car fabric almost. The assembly line for us is the bits and pieces that we get from outside that have to be formed in a way that we can lift it with the crane, so we can utilize the crane. It has to suit the dock size. […] So yes, we will customize the design to the way our assembly line is working.
A8. Implementation of Integrated Work Packages	**Respondent #25:** when you go to an integrated SPS/SURF [contractor], there is no benefit unless the contractor also handles the FEED part. We have to be working here [points in the paper] at the design stage. You can't have a third party who doesn't know the details about our subsea systems and our installation capabilities doing a FEED which suits us. And if they do just a general FEED, then you won't get the advantages of any of them.
A9. New Platform Concepts	**Respondent #29:** what's the idea behind [name of concept developed by company]? It's really developed as an alternative to the conventional ship shaped [platform hull]. The weathervaning is done in harsh environment. If it's in West Africa, you just use spread mooring systems. While North Sea, Australia, to some extent, Brazil, use turrets for mooring, that's the expensive part. So, we've seen that by taking that out of the equation, we have the same steel weight, same cost for a hull as a ship shaped, but we don't have the turrets. And in the regions that we are looking at, that is between ten and 30% of the total cost.

B. How Exploration Is Organized:	
B1. Through Different Front-End Phases	**Respondent #24:** The process that the oil companies go through is this fairly well-established stage-gate process. You define what you want, first of all, and then you start to put together a long list of potential options or potential ways of solving a problem and then going through this very organized stage-gate convergence process to slowly narrow down options that are not attractive, retain the ones that you think are attractive, carry them forward into the next phase where you spend a little bit more money and then slowly narrowing down to where you have the one solution that you then put into execution at what we call DG3. Because if we look at the timeline, we start with DG0, then DG1, DG2, DG3. DG3 is around about the same time as what we call Final Investment Decision, FID. So, if we start at the beginning, if you look at this from an operator's perspective, this is where they have an opportunity for some business and they're trying to evaluate 'do we want to go any further with this or not?'. Once they make this decision, they can pass through DG0. Then, what we will try to do is to evaluate, to identify a feasible solution that will work. So, during DG1 we might have a long list of many different ways of developing this asset. Here we go down to hopefully a shorter list and then we go into this concept stage, which is where we evaluate the short list in a little bit more detail, during DG2. Again, obviously at each stage we're spending longer, we're spending more man hours on each of these parts of the work. So, concept is generally a stage where we go from a shortlist down to ideally one solution.
B2. By Utilizing Various Types of Front-End Studies	**Respondent #70:** oil companies are requesting different levels of details and verification work in the different phases. In general, we break a project into these phases. We have the first contact with an oil company for a new field - we call it maybe a business opportunity initial phase, where we discuss the job to be done and we come up with an initial proposal for a typical size of our unit. After (it can be weeks and a few meetings and maybe a short report) we start what we call a feasibility study. In the feasibility study we get that all the disciplines engaged and

	we verify the concept we have proposed. This study can be anything from 1000 to 3000 or 5000 hours. So, it's relatively small study with the key disciplines involved. After we do this feasibility study, we do a concept study. In the concept study, we take all the different disciplines to the next level, and we add maybe also more disciplines. It can be many thousands of hours, many quite a high number of hours. In a smaller project this can be limited to maybe 10,000, maybe depends. After the concept study we should be ready for a FEED study. The FEED study normally depends on the way the operator wants to execute this project.
B3. By Increasing Studies in Design Maturity	**Respondent #58:** There you see the [study] classes. We have been involved in a lot of these classes and different companies are doing different notifications. But normally what we are engaged in, you can call it pre feed or concept phases or feasibility studies, et cetera. But the whole idea is that you narrow down the accuracy of both the weight and the cost as you move forward within these classes. And for most of these projects we are doing what we call a pre-FEED or a concept study. And then that normally leads into a FEED. Again, that is the basis for the EPC contract that we enter into in the end before we start actually doing the real stuff. Typically, the accuracy required within a FEED, as it says here, cost estimate of approximately 10%. And for a concept 15% and feasibility 25%. And then this is typically what [name of oil company] is requesting within such a deliverable, they have classified what kind of structural design needs to be looked at.
B4. By Including Multiple Suppliers	**Respondent #33:** most of the technical work being performed for the investment decision on [name of the field] was [made by] externally companies hired. So, we had extensive dialogue with a number of service providers, like [name of chosen FEED contractor] and other possible vendors. We issued a number of competing studies, to clarify the potential for the various development concepts. That was definitely the basis for the concept selection. Once we had done the concept selection, we continued with pre-FEED studies to get a better definition of the actual concept we wanted to mature before we issued the FEED studies that was done between DG2 and investment decision. […] We looked at floating vessels, ship-shaped and circular, we looked at jacket, I can't

	recall all the different solutions. We had different studies ongoing with different vendors to provide us with input on different solutions.
B5. By Ensuring Continuity of Contractors	**Respondent #52:** I think that it has been done quite frequently and we are still doing that [awarding early studies to contractors]. I think that what maybe has changed during the last 5, 6, 7, 8 years is kind of the acknowledgment that kind of having continuity on the contractor side is more important than we maybe thought before - having the continuity, knowing what has been the background, when you come into the sanctioning phase. Why have you selected whatever solutions and concepts and whatever. So, having a good history and a good knowledge about that in the early phase work.
B6. Through the Use of Competition B6.1. FEED Competition	**Respondent #50:** we changed the philosophy from [name of project] where we had an engineering contractor that did both concept studies and FEED studies and then that was the basis for the tendering. We did in a way that I prefer more, where we actually involved the key suppliers early like [name of 3 contractors]. And we had also a couple of other SURF [subsea umbilicals, risers and flowlines] contractors. [We had] informal parallel studies in concept, and then we did the FEED competition. We had actually brought [name of 4 contractors] on board on the SPS [subsea production system] side. We had two or three SURF contractors. [This was made] to get ideas on the table, quite a lot of ideas were generated. So, we did steer it ourselves to a large extent and then we screened out so that we had two SPS supplier and two pipeline suppliers. And then we did the FEED competition with those four. And then that was a FEED to tender process and therefore we did a cost split because they will then save the tender cost. So that was, let's say, a win situation. We did do a cost split, as I said on that study because it was a combined study and tender process. […] Then, instead of doing generic design, we really got down to nuts and bolts and managed to optimize the technical solution based on their products and how we could combine it. And, also about cost and schedule, went into the, let's say, manufacturing slots available, their schedule, vessel schedules and we really managed to tweak things and we actually shifted some of the scope from one season to

	another to actually get certain benefits. So, we actually managed to squeeze a lot of good improvements out of that process.
B6. Through the Use of Competition B6.2. Pre-FEED Competition	**Respondent #34:** then, you make your concept select and then you mature the selected concept efficiently to pass DG2. And on [name of project] they also had the tendering process. So [name of suppliers] were competing on their pre-FEED studies. But like on [name of project] we were working with [name of supplier] and other ones up to DG2. But in the FEED phase, in order to save some money, we only went on with FEED studies with [name of supplier] because it was a giant scope.
C. Why Contracting Innovations Are Used:	
C1. To Explore Various Contractors' Strengths	**Respondent #63:** I think the other key benefit is that we know who is going to do the job from the beginning. So, the concepts, the solutions we select are targeted for their technology, their facilities and their capabilities, or our joint capabilities. Now I think we see a clear benefit. We have been working together with our key suppliers from the very early beginning of that project and we clearly see the benefits now of that.
C2. To Explore Contractors' Competitive Advantages	**Respondent #18:** we worked on the model of integrating SURF and SPS, and we told the market that to provide the most value you need to bring us in early. Then we can optimize the field for you come with new technology ideas, work smarter, reduce the risk and sort out all the interfaces that you used to deal with. We can do that for you. If you award us an integrated project, we are willing to take on more risk. But at the same time, the total risk is lowering because we have better lines of communication. Everything inside one company is smarter than two separate companies and you need to make a contract to each of them that is without any holes, if you understand that.

C3. To Explore Alternative Concepts	**Respondent #70:** you have selected a concept and they can choose to develop the field in many different ways. I mean, it could be with a floater [floating platform], it could be a tie back to an existing floater or subsea development. There're so many different ways to do it. And it could be with a smaller or big storage capacity. And also, if they have decided at some point they want it to be a floater, they can still run ship shaped floater and a circular floater in parallel all through the concept phase, even into FEED. They can run two different concepts in parallel if they choose to.
C4. To Explore New Design Solutions	**Respondent #71:** when we started the study work for the [name of project in the Barents Sea], we didn't have a reference from all these North Sea developments. So, we started looking at all the design issues that were not known in the industry. We tried to gather information and we developed the technical solution in combination with our clients and we tried to learn how we could adapt to these more extreme design requirements. That differs from what is seen in the North Sea and the harsh environment with large waves and so on which are well known from the North Sea. But the additional impact as the low temperature, the cooldown exposure to personnel, exposure to facilities, is definitely a challenge to the teams that shall develop facilities for the Arctic region.
C5. To Explore Solutions to Different Problems from a Systems Perspective	**Respondent #37:** there are simply so many options, and some of them have bigger impact than others. But it's very rare that we engage the vendors on the same terms. It's more like, what if you have a chemical problem, which ways to dissolve it? I mean, if you have a chemistry problem, which maybe one or two of them would look at variants of that while someone else would look if you have a hydrate problem, meaning that you have high pressure that freezes across a pressure drop, maybe someone has well, maybe you have an installation problem. So, someone will try to circumvent that. But the problem is often you cannot only study the isolated problem because the equipment design or the module design has to fit into the system design. So you often have to study, even if what you want to study. Let's say you decide you want to try or look at subsea separation, but that's not sufficient because even like a company that comes up with a way to do subsea separation, however they want to

	do that, you also need to design the corresponding infrastructure, whether that is on the platform or fully subsea with link to onshore. The design space is simply so large that when you put out this, it's often done in an early phase, like for [name of project]. By the way, at the time you do this you have insufficient information so you simply do not know which one of these will even work.
C6. To Explore New Technologies	**Respondent #50:** we would typically ask a contractor for what type of technology would you suggest for this type of project, what are the technology readiness level as you indicate and what are the potential likelihood for success and schedule implemented. And then you would of course consider that. Do you go with the technology qualification here or do you wish to go for conservative existing technology? This is a strategy that you would consider but it's also decision making through the project. But you asked about the challenges here. There is a tradeoff here. If we go to a contractor and ask them to do a concept study, the downside with it is that they design the concept so that they are the only one that is able to deliver it. And you don't want to that you want to have competition further or often you want to have competition further, sometimes you don't because there is argument for going with the contractor, no history and modifications or whatever.
C6.1. From different environments	**Respondent #53:** when I came to spend some time in Houston, we typically took some of the technology we had used on NCS [Norwegian Continental Shelf] already, and we did some studies with the contractors in the US for trying to look into, for instance, [subsea] separation technology in deeper water in Gulf of Mexico. So, there was quite a lot of studies in that respect to try to adapt some of the learnings from NCS into an international context and also to learn the industry a little bit more.
C6.2. Developed in recent projects	**Respondent #7**: we knew we needed heated pipe. There was several options available for how to heat the pipe. So, ETH was one of the options. There were several technologies that we looked into and ended up with the ETH as the most practical for our project. We also looked into several other technologies in other areas and did the

	screening of what could be relevant for us and sort of closed them out as went along. We ran a parallel design competition in Surf with [name of two suppliers]. We had to choose these because they are the only players capable of the ETH piping and they only had one vessel available for each company.
C7. To Explore Opportunities for Creating Value	**Respondent #53:** Very early you start to establish some sort of procurement strategy, some sort of overall idea on how to get the best value out of this. And what we kind of have realized is that the earlier you do that assessment, the more value you may be able to get out of the work with contractors. Also, because you do not want to end up in a sort of a single source situation in any part down the road there, having more than one contractor involved in early phase work will give you more competition when you actually are making the final decision. So sometimes there are different ways to the goal there, but at least to think it through is very important. And what you can do is to design competitions. So we have several companies working in a sort of competitive mode to give you their best shot.
C8. To Explore Materials and Standardization Efforts	**Respondent #66:** there was room for optimization they could then of course do more engineering to come up with, let's say simplification, standardization, cross section design on the pipeline, material selection so there were plenty of opportunities for them to still, let's say mature it and optimize further. But the basic building blocks and layout and that kind of discussions were already completed.
C9. To Explore Market Competencies for Portfolio Decision-Making	**Respondent #24:** [Stage-gates] are very formal processes. And to go through those gates, they will need certain information to be able to make those decisions. And some of that information will come internallly within the operators. Some of it will come from the market, from us. And the increase in supplier led or early engagement with suppliers means that we're providing more and more of that information into the customer's decision-making process.
C10. To Explore Contractors'	**Respondent #24:** we do this every day. We know exactly what things cost, we know how long things take, we

Knowledge of Their Solutions	know where the risks are, we know the supply chain very well. So, we feel that we are able to not only price work a lot more accurately, but understand what the best solution is, what's going to be simplest to install and commission, what's going to be simplest to operate, what can be done within the schedule that's set where the risks are is very important. A lot of this is about risk management, but we feel that we're best placed to understand what those risks are, both technical and commercial risks.
11. To explore contractors' knowledge about costs	**Respondent #53:** a big thing for us also was to understand the differences in cost levels between different regions. That is like Brazil and Gulf of Mexico and NCS has a different cost level. There are different things cost drivers. We also do some studies in the early phase to understand some data that we typically give out multiple studies to more than one vendor to get sort of a wider context.
C12. To Explore Contractors' Creativity	**Respondent #55:** we always do concept studies with contractors prior to concept select. It is of course varying how much you do it, but you would always do some kind of screening studies, cost estimating and scheduling prior to going into a concept selection. The main reason for it I guess is internal capacity. You do not have the internal capacity in oil and gas companies to perform studies to this level. And you would also like contractors to be familiarized, because they should bid the scope later. They should propose their own technology and their own solutions, so they kind of use their creativeness. And they should also be participating with their cost estimates methodology, their scheduling, their tools, their vessels, their yards, their facilities, to understand that.
C13. To Explore Contractors' Ability to Improvise During Execution	**Respondent #42:** [For] both the Drilling platform and the Living Quarter, we utilized the same subcontractors in Poland, and the drilling platform was ahead of us. Then, the drilling platform got in trouble with the performance or the progress for different reasons. And the subcontractors in Poland start to get in trouble because I want to get in with my parts, but the Drilling [platform] wasn't finished. We saw that we would be delayed or at least it was going to cost us a lot of money if we had to go to other places. So, we had a meeting in [name of yard]. I said,

	okay, we have other yards in the east area, especially in Poland, a smaller yard. I can try to subcontract some of this stuff into this yard, bits and pieces of this to gain time so we can get it done and then we can get into the main yard and put it together when [name of other contractor] has disappeared. Little bit of discussion. And I said, okay, what does that cost? It was about 20 million. So, I said it will cost us extra because we had to ship material to all the hours. I need side people to follow up and all of that. One week later, they had agreed.
D. Benefits or Rationale for Joint Exploration:	
D1. Reduction of Costs	**Respondent #71:** Actually, that concept study was, I think, the longest concept study we have ever done. But part of that was not only the new area of the Arctic nature, but it was also the situation that when that study was initiated, the oil price was high. It was more than the $100 per barrel. And during that period the oil prices were dropping. So, a large part of that concept development was to improve the concepts with respect to the commercial situations, to reduce the cost of development. And that was really done very well in combination with [name of two oil companies] working together.
D2. Simplification of Design	**Respondent #71:** it was not one or two unique areas, but it was to look at all requirements. And that was also the operator that kind of relaxed on their requirements and did the assessment of what is the technical commercial necessities then for the design team to look at simpler ways to do it, but still to maintain the robustness in design but making it a less expensive way. And they actually did that. I think they managed to reduce the cost of development in the range of 50% or something. I think all these figures you have to get confirmed by others. But that's the story I know.
D3. Sharing Information About Costs	**Respondent #18:** what we want to tell the operator is ‘why do you go to the independent to do the FEED study? They don't really know the price level’. If you want the exact price, if you want to lower your risk or better

	evaluate the profitability of your project, you need to go to the supplier because they can give you the best price. And they also know what today’s technology is because these independent engineering houses, they don't know what is cutting edge technology because they can only refer to what has been delivered in the past.
D4. Reduction of Time	**Respondent #18**: what is also very interesting is that more and more we see that the new way of operating means that we are doing the FEED, we are also tendering at the same time, with the target price we need to commit, and we are also starting the project. Because they want to accelerate first oil. To compress schedule, we do the FEED and start the project. In the old days we would do the FEED, send the report, close that down; it would take two months and we would get the ITT for the tender, where we would do the final competition. We would submit the tender after three months, then we are given two months evaluation and then we would get the contract. Then we start.
D5. Optimization of Design	**Respondent #30:** the tradeoff for the oil company is: “I can lose four to six months [with a tender], but I can use the EPC competition to drive the price down.” But you may end up with a contractor who is not that familiar with the job, who may have been pricing the job very aggressively, and it may not be a realistic price. […] If the FEED is optimized to make sure that as many companies can compete, then that is sort of one model. But if you actually do the FEED in a way that the EPC or the fabricator has the best way to build as cheap as possible, that’s actually a big difference. There are differences in methodologies for how each of the actors will price and construct the “house.” Some have strong carrying beams, some have strength in the walls, there are all these different types of engineering grips that you can do. And the difference is that, when the plan is to roll it over and to have a seamless transition, then you prepare the FEED in the way that reduces the nominated contractors’ construction cost
D6. Increase in Maturity	**Respondent #66:** You will of course have a completely different maturity level because you have worked with

	the supplier, the ones that are designing and delivering and installing the equipment for much longer.
D7. Reduction of Tender Costs	**Respondent #66:** And the risk premium that the contractors will add to the tender is also higher because it's not their solution. They haven't engineered it; they haven't worked with it for that much. So, then it's less mature. So, it's a higher risk for them. Interface risk, for example. So, we achieved quite a lot in terms of reducing the cost from [name of project] to [name of project], actually.
D8. Sharing of Responsibility	**Respondent #32:** You say, 'oh, you take full responsibility for the FEED. [name of some other contractor] delivered this FEED, but you're awkward and you have to take full responsibility. And so, obviously, then you come in the project execution phase, and they say, 'oh, I didn't understand what they meant by that. This is costing me a lot of work'. Because of that, we are now trying to work closer with them in an early phase to see how they can take full responsibility for the design throughout the project. I think that's one of the biggest drivers. And then we also see that we could save time. We can order the long lead equipment earlier. We don't have to take responsibility. You often find that also in execution, that the long lead equipment is a driver. So, a very common way to come around that is you will place the long lead equipment items maybe before.
D9. Enhancement of Efficiency	**Respondent #30:** in the traditional way, oil companies define the lever for value creation as competition after the FEED stage. That's how the companies believe that will generate the highest amount of value. But I think that increasingly it's recognized that maybe that's not necessarily the case. […] Instead, you do the competition prior to getting the FEED, then the job is priced during the FEED, and then some of the steps that you need to take anyway, you front-load [i.e., prepare for execution] and you put into the FEED phase, so you have a much more efficient planning process, in order to get the project completed earlier.

5. Findings

5.1. Summary of papers – a lifecycle perspective

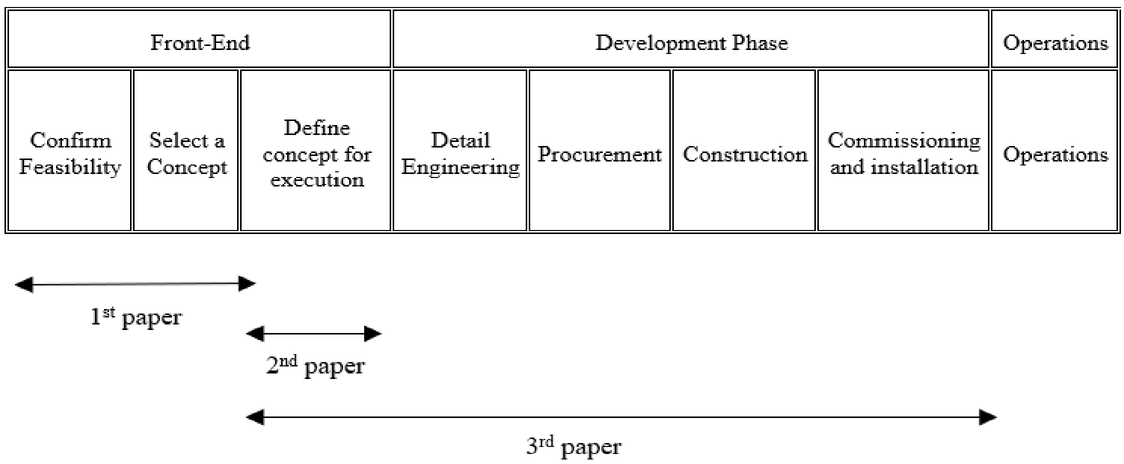
The papers in this thesis are organized according to critical opportunities for innovation that are presented at different lifecycle phases of megaprojects. The lifecycle perspective is useful to respond to the research gaps in a systematic way, building on the argument provided by Davies et al. (2014) that opportunities for finding new practices, processes and efficiencies emerge over different phases in a megaproject, and that owners need to develop capabilities to seize the opportunities when they arise.

The first paper focuses on the early phases of the front-end, where evaluating alternatives is a crucial task for innovation. Contractor involvement during this project stage is commonly referred to as early contractor involvement. In Norwegian offshore projects, front-end studies, called appraisal, feasibility, concept, and FEED, have been used to organize early contractor involvement. The primary research question for the first paper is how this form of early contractor involvement facilitates exploration and exploitation during the front-end phases of megaprojects.

The second paper examines the later phase of the front-end, occurring after a concept is selected but before an execution contract is awarded. This stage offers opportunities for optimizing design with constructability input and creating synergies between planning and execution sub-phases. In the offshore industry, oil companies have started awarding contracts that integrate this last planning stage with execution contracts, known as two-stage tendering. The second paper seeks to comprehend the reasons behind the adoption of this contracting approach in the offshore industry and how it influences ambidexterity.

The third and final paper takes a comprehensive view of the megaproject lifecycle, with a specific emphasis on the execution phases: detailed engineering, procurement, construction, and installation. Megaproject delivery is heavily influenced by uncertainty, making innovation for adaptation and responsiveness crucial. However, encouraging adaptation becomes complex when multiple contractors are involved. Therefore, the third paper aims to understand the processes that project organizations can employ to achieve a balance between routine and innovative actions in complex project coalitions amidst uncertainty.

Figure 4: A lifecycle perspective



Essential background information for understanding all papers is the range of technologies and processes targeted during the exploration in the front-end phase of the offshore industry. This encompasses various aspects, such as Electrification (A1), Standardization (A2), Design of Steel Structures (A3), Power-from-Shore Technologies (A4), and so forth. The inclusion of these aspects highlights the multifaceted technological advancements within this field and other management innovations.

In Paper 1, the emphasis is predominantly placed on the organization of exploration through front-end studies. This includes the analysis of different front-end phases, the utilization of various types of front-end studies, and the engagement of multiple suppliers, among other factors. There is also a substantial focus on why front-end studies are used, examining aspects such as the exploration of different contractors' strengths and creativity, as well as opportunities to create value.

Paper 2 builds on the themes explored in Paper 1, placing a more substantial emphasis on ensuring continuity of contractors and the use of FEED competition and Pre-FEED competition in the context of two-stage tendering. The centrality of these codes aligns with the paper's focus on the importance of continuity from FEED to EPC, as well as the vital role of competition. This paper also extends the analysis to the benefits and rationale for joint exploration, an area not examined in the first paper. It delves into a comprehensive understanding of two-stage tendering, exploring its benefits and rationale, with a particular concentration on aspects like the Reduction of Time, sharing responsibilities and the Enhancement of Efficiency.

Paper 3, while touching upon some of the benefits, such as cost and schedule reduction, takes a distinct direction in its exploration. Its primary focus lies in the investigation of how oil companies explore contractors' ability to improvise during execution. This singular focus distinguishes Paper 3, situating the ability to improvise as a major, potentially transformative element within the context of offshore exploration and development.

All three papers are single author papers. They have different target audiences, which has a slight impact on the way they were framed.

Paper 1: The role of early contractor involvement in facilitating exploration and exploitation in megaprojects

The earliest phases of the front-end, before a concept is selected, are the period of highest indeterminacy in a megaproject, when many different technical alternatives can be appraised. The first paper addresses a gap in project management research regarding how collaboration with contractors can nurture ambidextrous capabilities within project organizations in these early phases of megaprojects. Despite the recognition of ambidexterity's importance, there is a scarcity of knowledge about its implementation in scenarios where contractors have the ability to both explore innovations and leverage lessons from previous projects. The emphasis on early contractor involvement in the front-end phases, where ample innovation opportunities exist, is particularly noteworthy.

This study offers three contributions to megaproject research, emphasizing the role of early contractor involvement in advancing both exploration and exploitation activities. The first contribution indicates a trend toward favoring recently developed innovations over established solutions, with minimal emphasis on radical innovations. The second contribution identifies two mechanisms by which early contractor involvement facilitates project ambidexterity: first, it streamlines the temporal separation of tasks, allowing for quicker transition from the exploration to the exploitation phase; second, it promotes a structural separation between exploration and exploitation tasks. This allows contractors to apply their existing expertise to refine innovations, while enabling project organizations to explore new solutions differing from their previous approaches. The third contribution introduces external search breadth as an influential factor, suggesting that a broader range of external collaborations enhances the likelihood of innovative outcomes. This study provides a conceptual framework for optimizing contractor collaboration in the front-end phases of megaprojects to support both exploration and exploitation activities, using the concept of external search breadth.

Paper 2: Investigating the Adoption of Two-Stage Tendering and Its Role in Facilitating Ambidexterity: Insights from the Norwegian Upstream Offshore Oil and Gas Industry

The second paper focuses on the third and last phase of the front-end of offshore oil and gas megaprojects, when a concept is selected, but no final investment decision has been made yet. At this stage there are additional steps to be carried out before the project is approved for development, especially in deciding the delivery strategy, e.g., scope of activities, total execution costs, allocation of risks, etc. Opportunities for innovation still exist after concept selection, but they will be more focused on optimizing design and creating improvements for execution. The paper addresses a novel contracting strategy used to create room for joint innovation, called two-stage tendering. It is an innovative way to organize early contractor involvement while still keeping competition (if desired) or to share ownership of design choices with the supply chain.

Among the contributions of the second paper are that it sheds light on the adoption and advantages of the two-stage tendering model, offering project owners a strategic approach to enhance project outcomes. The paper underscores how this model optimizes design for construction, provides contractors with greater ownership of technical definitions, reduces time and enhances efficiency. Secondly, the concept of contextual ambidexterity is introduced as a pivotal outcome of two-stage tendering, emphasizing how it empowers contractors to balance exploitation and exploration, ultimately leading to innovations in design and efficiency gains during project execution. Lastly, the paper emphasizes the benefits of two-stage tendering, challenging traditional contracting methods and highlighting the potential for predictable delivery, optimized design, and shortened development phases.

Paper 3: Balancing routine and innovative action in complex project coalitions: a case study of the Johan Sverdrup 1 megaproject

The third paper has a broader lifecycle perspective, from the front-end to installation, with focus on execution phases, like detail engineering, procurement and construction. For megaprojects, this is the culmination of many years in planning, up to decades, sometimes. Hence, chances are that unplanned events will disrupt original plans, putting pressure on rigid project relations based on risk averse contracts and traditional work processes. New forms of contracting have been developed to encourage collaboration, based on contractual incentives, risk sharing, early involvement and co-integrated team. However, the literature so far has produced little evidence that these collaborative elements are sufficient to ensure a successful delivery in complex project coalitions. It is very challenging to manage a large number of independent firms in collective contracting arrangements.

The third paper in this thesis raises four issues with multi-firm megaproject environments: (1) lack of design maturity; (2) conflicts with different processes and information systems; (3) the temporal dimension of interdependencies; and (4) lack of responsibility in following-up execution. These challenges can minimize the potential of collaborative arrangements.

The findings show that as project settings become more complex, the interaction with multiple contractors requires complementary governance mechanisms to balance routine and innovative action. While some of these processes are geared towards enhancing stability to facilitate efficient project routines, others play a pivotal role in fostering collaboration between contractors and the project owner to proactively address challenges and explore new solutions. Four strategic processes were identified in the research. They are summarized as quality of Front-End Engineering Design; familiarization periods for seamless handover from design to execution; interface management routines; and collaborative follow-up.

6. Discussion

6.1. Exploration and exploitation in the offshore oil and gas industry

According to Cantarelli and Genovese (2021), innovations in megaprojects can manifest as either radical or incremental changes, and they can be related to products, processes, and business models, while also varying in novelty to the firm, industry, or the world. Given the thesis's focus on ambidexterity in projects, it aims to explore the dynamic relationship between two distinct types of innovations: incremental innovations, reflecting exploitation, and radical innovations, reflecting exploration.

Offshore megaprojects have a core objective of creating large-scale, customized infrastructure to extract, process, and transport oil and gas for commercialization. Such projects may require one or multiple platforms hosting processing plants, living quarters, drilling packages, and storage. These facilities can either be fixed to the seabed or float on various types of hulls, utilizing different mooring methods. Additionally, the offshore infrastructure incorporates a sophisticated subsea equipment system responsible for controlling the flow in and out of wells, extending the operational site beyond the platform. Extensive networks of pipelines, spanning kilometers across the field, connect the subsea equipment to the platforms.

Following Cantarelli and Genovese's (2021) categorization, radical innovations involve the introduction of new technologies or facility designs previously unexplored by the concessionaire group—the consortium of oil companies owning the rights to develop the field. Conversely, incremental innovations entail changes to existing designs and technologies previously utilized by the oil company in other projects, but tailored to meet site-specific conditions, stakeholder requirements, or capitalize on opportunities for cost and schedule reduction.

The research identifies examples of radical innovations, such as novel platform concepts like spar platforms or circular ship-shaped FPSOs, the selection of new subsea production concepts and equipment, the adoption of power from shore solutions to electrify platforms, and the implementation of unmanned platforms for remote operation. Similarly, examples of incremental innovations include the redesign of subsea production system layouts, combining insights from different disciplines (pipeline, installation, and subsea equipment), customization of platform designs previously employed in other projects, and adaptation of project plans to accommodate new construction methods. These distinctions provide crucial insights into the dynamics of innovation in offshore megaprojects, highlighting the interplay between exploration and exploitation efforts.

6.2. Contracting innovations in the Norwegian offshore industry

This thesis addresses unexplored topics in the intersection between innovation and project management. The overarching theme of the three papers is how megaproject organizations can adopt new forms of contracting to collaborate with contractors in their joint pursuit of (incremental and radical) innovation. In the last three decades, new models of contracting were created to improve the coordination of megaproject networks and bundle different project activities in one commercial interface. A key distinctive feature of these new forms of contracts is to create incentives and freedom for innovation to be realized.

Since project studies have advanced the proposition that contracting and innovation are closely related (Davies, Gann and Douglas, 2009; Gil, 2009), many issues with respect to how and when to encourage innovative ideas through contracting have remained unexplored. The combined findings from the three papers in this thesis reveal the emergence of new elaborate forms of contracting used by oil companies to make better use of suppliers' existing knowledge and foster exploration during different phases in a megaproject's lifecycle: first, when their utility is at its highest (paper 1); then, when ideas gradually turn to more practical issues like construction optimization (paper 2); and finally in the development phase, when project routines must be changed to cope with opportunities and challenges (paper 3).

To understand how contracting strategies can enhance ambidexterity, this thesis suggest that contracting should be viewed in a more holistic way, encompassing more than just the payment form or the integration of project functions like design and execution. The contracting innovations described in this thesis enable project organizations to explore innovations in different ways, which can only be identified if one considers the strategic point of entry for contractors from a lifecycle perspective. The activities in the front-end differ drastically in scope, going from assessing the feasibility of alternative solutions, to drawing the conceptual design, and finally to completing the basic engineering work. Depending on when contractors are actually involved in the front-end, they will have greater or lesser influence on how the project progresses.

The contracting innovations in the offshore industry are described below, from a lifecycle perspective.

6.2.1. Contracts for appraisal, feasibility, and concept studies

The first innovation identified in the offshore industry is the award of standalone studies during appraisal, feasibility and conceptual stages of the front-end. This happens at a very early phase in the project's lifecycle when the contours of the project are not yet determined. In that phase, oil companies are still undecided about a development concept and thus seek the inputs of EPC contractors and systems vendors about several alternative technologies and production systems.

These front-end studies are not informal advice. They are pre-construction and consultancy services provided by contractors under reimbursable contracts. This is an innovative form of making decisions in the front-end, based on information provided by contractors, as early as possible, about numerous development options. They are referred as standalone, because, unlike other forms of early contractor involvement, front-end studies have a limited scope and duration. Suppliers are paid for the study, but that does not necessarily indicate that they will be selected for the execution scope.

There are three types of study contracts that precede concept selection in offshore megaprojects. They all follow the structure of the front-end under the FEL methodology (see figures 2 and 5). Appraisal studies are superficial studies, with uncertainty about costs in orders of magnitude. Their purpose is to prove the economic potential of the discovery and for oil companies to understand the realm of options available to develop a field. Feasibility studies are more detailed and quantitative type of studies, used for more promising concepts. There is also a lot of space for proposing improvements or customizations. Once operators have narrowed down the possibilities to one or very few alternatives, then operators award concept studies, in which all the disciplines are taken to higher levels of detail. As the name suggests, concept studies are made to prepare the project organization to formally select a development concept. Paper 1 focuses on how this innovative form of contracting and how it improves the exploration capabilities for megaproject innovation. Oil companies can award several suppliers with concept studies.

6.2.2. Two-Stage Tendering or FEED + EPC contracts

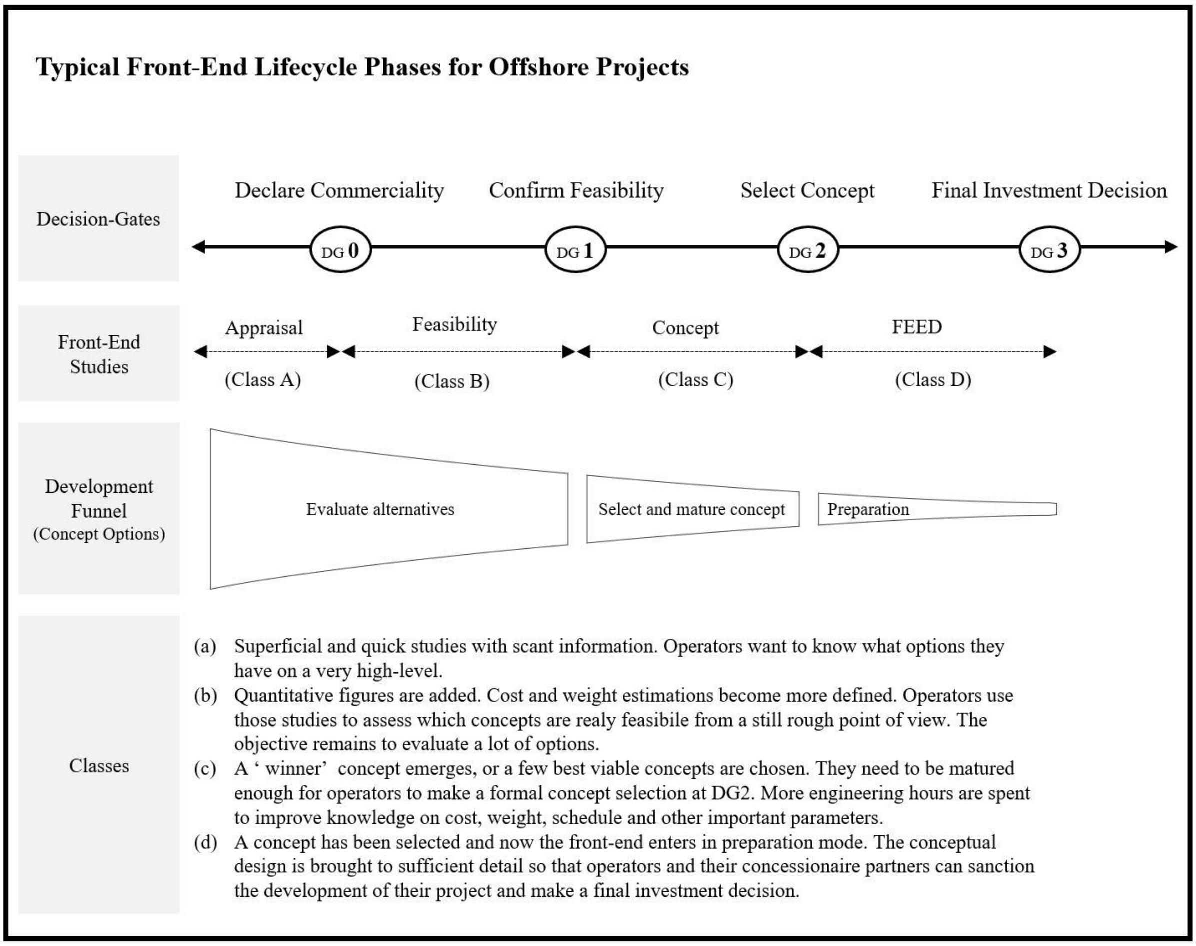
A second innovation is the use of two-stage tendering in the offshore industry. The principles of two-stage tendering are that, at a first stage, contractors tender to an incomplete scope of work that has been priced provisionally. They finish completing the design, seeking areas for optimization, and adding their own execution strategy. Then, at a second stage, they propose a fixed price for construction based on a more mature design. Provided the price is competitive, a complemented contract is awarded for execution.

In offshore oil and gas, two-stage tendering is equivalent to the use of FEED studies in combination with EPC contracts. FEED is the last part of the front-end, after concept selection, which serves to mature the development concept for a final investment decision. FEED studies involve in-depth engineering analysis, technical specification, and cost estimation, providing a clear roadmap for project implementation. During FEED, cost and schedule must be estimated as precisely as possible, usually with 20% of cost uncertainty. A FEED + EPC contract means that a contractor is selected to perform a FEED study based on a high-level conceptual design, and the oil companies award the same contractor the execution contract, without putting the FEED out to tender. Execution is typically made under an EPC basis, a turnkey-type contract that integrates detailed engineering, procurement and construction activities.

After decades of reporting on performance problems in offshore projects, a consensus was formed in the Norwegian industry that cost overruns can be mitigated when contractors are involved in the front-end. Many industry reports have emphasized the importance of FEED (or Front-End Engineering Design) studies to mature design for platform construction and subsea systems delivery. Without a FEED, operators would award EPC contracts with low levels of detail in the preliminary design, containing little more than a functional specification and main operational requirements. This creates room for innovation but at the same time the main elements of basic engineering have not been matured sufficiently to estimate the execution costs with more accuracy.

Two-stage tendering is a solution to create freedom to innovate and still increase predictability in delivery. FEED + EPC has become a prevalent way of organizing early contractor involvement in the Norwegian offshore industry. Contractors can optimize design using their execution knowledge and provide oil companies with more realistic estimates for a final investment decision. This innovative tendering technique is well known among practitioners but has received very little academic attention.

Figure 5: Front-end studies described in paper 1 and 2



6.2.3. Collaborative governance of offshore megaprojects

Outsourcing studies in the front-end is one way how oil companies collaborate with the supply chain to deal with issues of adaptation and innovation. This thesis also identifies other practices adopted by oil companies to organize joint work with contractors during execution. The objective here is to improve performance by encouraging innovation, in the sense that it challenges contractors to change some of their project routines and explore innovative solutions.

The scope of offshore megaprojects is too large for one contractor to perform everything alone. Usually, offshore infrastructures are decomposed in work packages and awarded to several contractors. To organize collaboration in multi-firm environments, oil companies have developed innovative processes to reduce chances of conflicts between interdependent activities. This happens after the feasibility, conceptual and FEED phases.

The first innovative approach to contracting in the development phase of the project's lifecycle are the familiarization studies to create a controlled handover from design to execution. Given the organizational complexity of offshore megaprojects, suppliers will step in at different phases. Some during conceptual design, others during detailed engineering and others during construction. When engineering firms have to interface with many contractors, oil companies can make sure that the contractors are familiarized with design.

Paid familiarization studies mean that contractors are compensated by the time and resources they spend to understand the design basis before being awarded the work, checking if there aren't critical errors and also influencing design choices. This can result in the FEED being adjusted to fit the contractors' way of executing the project. This can also be undertaken as a post-FEED study, also paid by oil companies as a means to prepare for execution and avoid do-overs months or years later. In this familiarization period, engineers from different organizations must collaborate, with the intermediation of the oil company.

Oil companies also spend money early in the engineering stages to create forums for sharing and solving problems. The objective is to ensure that the progress of the systems design is coherent, especially when there are technologies (like automation systems) cutting across different work packages. Database systems and dedicated project teams were created to ensure that technical information is shared in the project organization and answered timely. In addition, oil companies also establish interface meetings regularly to improve how technical inputs and problems are addressed. The idea was that each work package is not an individual project, but part of a larger scope, even though there wasn't a single multi-party agreement signed by the contractors. This makes problem solving much faster. The same rationale can apply to execution follow-up, when oil companies can appoint several people from their organization to oversee the progress of in the construction sites and be proactive with problem solving.

6.3. How contracting innovations impact joint exploration

Project management research recognizes the importance of temporal separation between exploration and exploitation activities (Liu and Leitner, 2012; Sergeeva and Ali, 2020). This temporal dimension is especially pertinent for projects given the progressive lifecycle phases that they inherently undergo. Although standard project management methodologies allow for some dedicated time for exploration in the early stages of the front-end, this period for innovation search cannot be undertaken indefinitely, as project stakeholders develop expectations about key milestones, guiding the progress of engineering and strategic facets of the endeavor (Jergeas, 2008). Upon the establishment of an organizational framework and resource allocation for project planning, the time dedicated to exploration becomes crucially constrained by the pragmatic need for progress. Understanding and effectively managing these exploration constraints are critical factors in optimizing project ambidexterity and fostering innovation.

The first paper of this thesis delves into how oil companies strategically address the exploration phase in the earliest stages of the front-end, by awarding front-end studies to multiple suppliers. This approach allows for the simultaneous exploration of a plethora of innovative options, while the supply chain is able to exploit their existing competencies. The strategic utilization of ambidextrous principles empowers oil companies not only to navigate the challenges of time constraints in the front-end, but also to enhance their ability to assess and assimilate solutions adopted in other projects, which are then replicated and recombined for the current project.

The collaboration with multiple contractors is facilitated by an organized convergence process, wherein alternative solutions are systematically evaluated, leading to the selection and advancement of the most promising ones to higher levels of detail. This convergence process bears resemblance to the concept of a development funnel and embodies the principles of temporal ambidexterity, allowing for the seamless integration of exploration and exploitation as the project progresses through its lifecycle phases.

While the first paper focuses on the initial stages of the front-end up until concept selection, the second paper of this thesis explores the final phase of the front-end, referred to as FEED in the oil and gas industry. This phase is a crucial juncture in the project lifecycle where organizations must refine and develop the selected concept, specify technical requirements, and estimate costs and schedules before moving into full-scale implementation. In a traditional contracting situation, the FEED would be done by an engineering firm, and it would be the basis upon which execution contractors would competitively bid for the EPC scope. The contracting innovation discussed in the second paper is generally regarded as two-stage tendering, or a FEED+EPC contract. Implementing a two-stage tendering approach enables longer and more meaningful collaboration with contractors than the traditional iterations during the bidding process, and gives them the opportunity to improve design thinking about how execution will be made.

In the final stage of the front-end, exploration opportunities for contractors become more limited, as many high-level decisions have already been made in the preceding phases. Nevertheless, there are still opportunities for contractors to exploit their competencies during the Front-End Engineering Design (FEED) phase. By tailoring the design to be fully compatible with their construction capabilities, contractors can effectively reduce costs, increase predictability, minimize rework, and optimize execution schedules. Additionally, the use of different selection processes enables oil companies to engage in targeted exploration. This can be achieved by having multiple contractors conduct parallel FEEDs with distinct proposals. To further encourage exploration, oil companies can organize design competitions before the FEED phase, combining competitive pressures with two-stage tendering techniques.

Although two-stage tendering is well-known among practitioners, its examination in academic case studies has been limited, with only a few instances or brief mentions in literature (e.g., Sergeeva and Zanello, 2018). This thesis not only acknowledges two-stage tendering as an innovative form of contracting but also demonstrates how it enhances ambidexterity. The adoption of a two-stage approach, coupled with competitive contractor selection methods, incentivizes contractors to innovate and exposes project organizations to a diverse range of ideas, while exploiting execution knowledge from FEED contractors. Simultaneously, this approach helps narrow the scope of the project design, guiding it towards a focused direction as it transitions into the development phase.

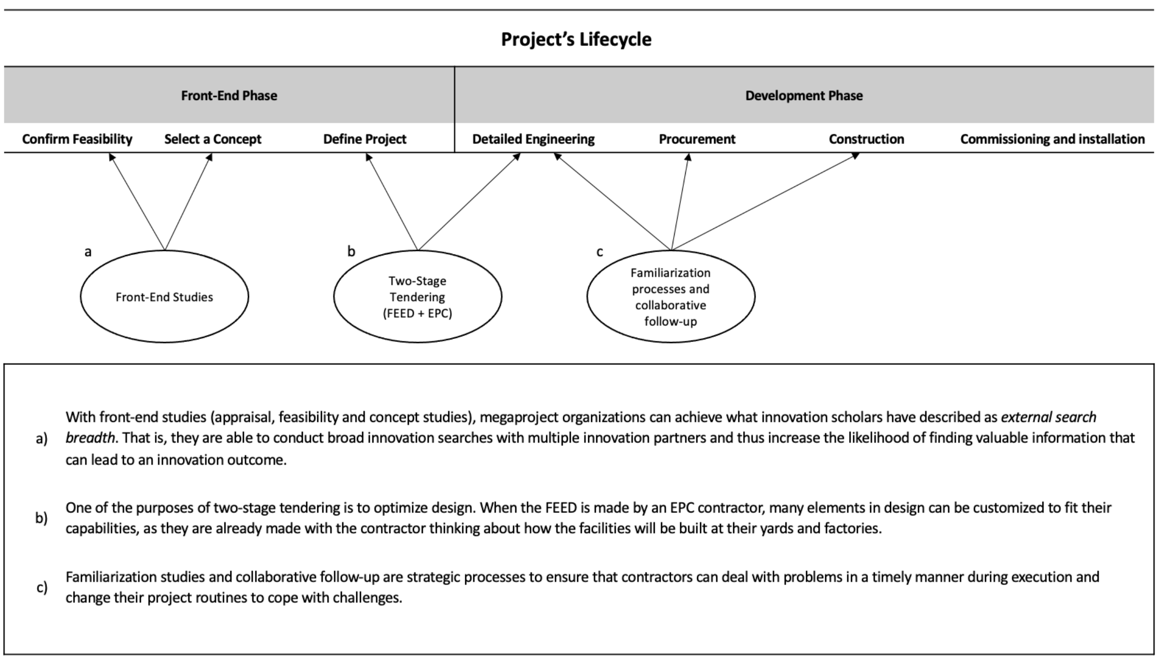
Lastly, once the megaproject receives approval for execution and contracts are awarded, the flexibility to incorporate new ideas diminishes significantly (Worsnop, Miraglia, and Davies, 2014). The project management literature emphasizes that contracting strategies should foster responsiveness and adaptation in the project coalition during the development phase. However, project actors often adopt a risk-averse approach, relying solely on traditional methods due to the perception that the potential benefits of innovating may not outweigh the risks of failure, such as cost overruns, delays, and quality defects (Davies, Gann, and Douglas, 2009; Gil and Beckman, 2009). Despite this emphasis on collaborative elements, the existing literature has generated limited evidence that these practices alone ensure successful project delivery in complex project coalitions. Managing a large number of independent firms in collective contracting arrangements poses significant challenges (Merrow, 2011). Additionally, not all organizations are familiar with collaborative practices (Pauna et al., 2021).

The case study presented in the third paper exemplifies the achievement of contextual ambidexterity within complex project coalitions. The paper focuses on the first phase of Johan Sverdrup, a US$ 15 billion megaproject. While the primary emphasis during the early planning stages of Johan Sverdrup was to exploit existing technologies and standard solutions, Equinor, the oil company responsible for the megaproject, proactively coordinated and funded numerous initiatives to foster adaptability in later stages. These initiatives were formalized as part of the project's standard way of working, aligning with previous research findings that suggest the creation of routines to provide space for exploration when conditions change (Davies, Dodgson, and Gann, 2016; Zerjav, Edkins, and Davies, 2018). Notable examples of these practices in the Johan Sverdrup megaproject included familiarization processes, forums for interface management, and an active follow-up strategy at the yards.

Consequently, contractors were able to adjust their working methods throughout the project's duration and promptly address challenges that arose.

The third paper makes a valuable contribution by shedding light on ambidextrous management practices within a complex network of several contractors, avoiding the necessity of a multiparty contract to create incentives and responsibilities for contractors to adapt their routines. The paper emphasizes the significance of flexible contracts based on reimbursable payment. However, it also highlights that the compensation form alone cannot guarantee project success, as many alliancing projects have failed to deliver optimal value for their owners. Notably, the Johan Sverdrup project exemplifies several processes, coordinated and funded by Equinor, enabling swift responses to potential threats to the project's successful completion. These processes include adjustments to the front-end engineering design (FEED), changes in engineering deliverables sequencing to match fabrication competencies at the yards, and rapid problem-solving when unforeseen issues arise.

Figure 6: Three contracting innovations from a lifecycle perspective



7. Concluding remarks

The primary goal of this PhD thesis is to emphasize the intricate relationship between contracting and innovation, with a specific focus on how new contracting strategies facilitate joint exploration in megaprojects. The pursuit of improved megaproject delivery continually drives the search for innovative practices, ideas, and technologies, which includes the adoption of novel forms of contracting (Davies, Dodgson and Gann, 2016; Gann, Davies and Dodgson, 2017). Within this thesis, three new forms of contracting are explored: front-end studies (appraisal, feasibility, conceptual, and FEED studies), two-stage tendering, and relational governance mechanisms utilized to foster collaboration within megaproject coalitions. These innovative contracting approaches, identified in the context of the Norwegian offshore oil and gas industry, enhance the ambidextrous management of megaproject innovation. They empower oil companies to exploit the knowledge present in the supply industry while simultaneously exploring alternative solutions to optimize the cost-to-quality ratio, increase operational value, reduce total lifecycle expenditures, and expedite project execution.

Taken separately, the three papers are practice-oriented and very much focused on the offshore industry, which influences their potential for publication in major project management journals. However, taken together, the three papers tell a cohesive story of how new forms of contracting are being developed to change the scope of collaboration with contractors to promote joint innovation. The fact that the offshore industry illustrates this transformation makes it all the more relevant, because the offshore industry has pioneered many innovations when it comes to contracting, which were later disseminated across other project-based sectors.

7.1. Contribution to the Globoil project

The purpose of my research as a PhD with the Globoil project was to dig much deeper into the contracting strategies of offshore oil companies, something that started with Sabel and Herrigel (2019) in the SIVAC book. To summarize Sabel and Herrigel's (2019) main points, on one hand you have the emergence of a model of collaborative innovation, where even the most capable of actors rely on a complex network of suppliers to co-develop their products.

On the other, there is the problem of uncertainty and complexity. Actors cannot anticipate future states of the world and account for that in detailed specifications to suppliers.

As a result, new forms of contracts have been created to facilitate joint innovation under uncertainty. What characterizes these new forms of contracting is that the buying/client organization does not fully specify an outcome. Instead, it sets general goals and milestones that can be revised according to unforeseen changes. To complement formal contracts, several processes are developed to govern the buyer-supplier relationship over a long period of time, such as regular meetings to review progress and procedures for resolving conflicts.

In general, there is growing recognition of the limitations of traditional contracts to govern complex relationships between clients and suppliers, especially ones that span many years. This concern has been expressed by research on the services sector (Frydlinger, Hart and Vitasek, 2019), product development (Gilson, Sabel and Scott, 2009), and in the engineering and construction (Roehrich and Lewis, 2014) and megaprojects (Davies et al, 2019; Gann, Davies and Dodgson, 2017). This has led to the development of new forms of contracting that allow for collaboration.

What characterizes these new forms of contracting is that different project actors are involved when the contours of the project have not been defined. Suppliers have incentives and freedom to propose optimizations. Because contracts are longer than just execution, successful contracting relationships are ones that include relational mechanisms such problem-solving routines, information sharing and integrated teams.

My thesis supports the original argument in SIVAC (2019) by reinforcing the principles of collaboration that lead to contracting innovations. Oil companies engage early with different contractors. During execution, the cutting-edge practice is to collaborate instead of keeping them at arm's-length, even when the relationship is not framed explicitly as a partnering arrangement. Furthermore, this thesis shows that oil companies have continued to advance early contractor involvement and relational governance mechanisms beyond the framework of partnering and alliances. This approach focuses on broad innovation search before concept selection; competitive and non-competitive forms of two-stage tendering; and stronger project delivery collaboration.

7.2. Contribution to project studies

The thesis contributes to the project management literature by shedding light on previously overlooked forms of contracting in project studies and describing how these innovative approaches can act as catalysts for joint exploration and exploitation in megaprojects.

Despite the recognition of contracting as a key mechanism to balance exploitation and exploration (Eriksson, 2013; Eriksson and Szentes, 2017, Davies, Dodgson and Gann, 2016), the prevailing focus in project studies has centered around partnering, with a primary emphasis on reimbursable contracts, integrated teams, or the bundling of design with execution. This study goes beyond these conventional approaches, revealing the untapped potential of innovative contracting strategies during feasibility and conceptual stages, as well as design competitions within two-stage tenders. Moreover, it offers valuable insights into how various processes during the execution phase can foster ambidexterity in complex multi-contractor environments, without resorting to multiparty contracts.

By adopting a lifecycle approach, this thesis emphasizes that the analysis of joint exploration must encompass multiple elements influencing project innovation, such as definition phases, stage-gate controls, and time constraints. As the project progresses through its lifecycle, the opportunities for innovation change, necessitating contracting strategies tailored for each phase of the front-end. By refining the search processes and effectively preparing for execution, these innovative contracting strategies hold the potential to unlock greater innovation and ultimately lead to enhanced project ambidexterity.

7.3. Implications for practice

It takes some time for practitioners to catch up to innovations in contracting emerging in other sectors. Megaprojects take many years to complete. Once they are delivered, probably a long time will pass until the project organization is involved in another one. The discontinuous nature of megaproject demand plus their lengthy lifecycle presents a challenge for disseminating innovation, because a novel practice might only be tested again in the same institutional setting many years later. This time lag effect on innovation is further exacerbated by a conservative mentality shared in project organizations due to the high risks of cost and schedule overruns.

The front-end studies and FEED described in paper 1 and paper 2 have been around for years in the offshore industry. Unfortunately, their potential to improve performance and innovation in other domains has remained unexplored. To encourage dissemination, the findings in my PhD thesis can be articulated as a series of simple rules for managers in other industries to select contracting strategies that foster innovation across the entire lifecycle of a megaproject.

The first rule is to have broad search strategies to figure out what is the best system architecture for the megaproject. This means collaborating with many contractors in parallel, placing small bets in different conceptual designs. Project organizations can use front-end studies to have early interactions with contractors and understand what they can bring to the project. It doesn't mean they will be chosen for execution.

The second rule is to bring contractors after concept selection and decide jointly how the execution scope will look like. Optimizing design, sharing ownership of design choices, and compressing schedules are some of the benefits of a two-stage tender. Owners can have more competitive forms of early contractor involvement if they want to reduce costs and not be dependent on one contractor's vision for the project. This is not conflicting with the first rule, because it happens in a different phase of the megaproject lifecycle.

Once a final decision with contractors is made, making all parties understand design is critical. Not all firms will be involved early, but they must understand the basis of their work. Customers usually distance themselves from execution by awarding turnkey contracts that transfer responsibilities with interface management and detailed design to contractors. However, it is important to have a watchful approach to how the work is planned, including further investments, if needed, in familiarization studies. These investments in collaborative processes don't stop until commissioning, because firms need to be innovative and respond to changing circumstances. A strong follow-up strategy involves more than flexible contracts. It needs a present owner.

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