The Norwegian oil and gas supply industry in hard times: innovation in global supply chains (GLOBOIL)

1. Relevance relative to the call for proposals

Innovation in the offshore petroleum sector takes place in a complex interplay between oil companies, an increasingly more integrated group of global dominant top suppliers, and a large, often more local, group of smaller sub-suppliers. In this evolving scenario the Norwegian oil sector increasingly requires learning from concepts, technologies and practices developed elsewhere. This dynamic applies for concrete technical innovation like reducing cost and improving accuracy and safety in drilling, as well as finding efficient combinations of different technologies, infrastructure and contract relations in large field development projects. In this project, we will study how Norwegian upstream oil and gas (OG) suppliers are adapting their production strategy, supply chain architecture and innovative capabilities to the demands of recent developments in global manufacturing. Understanding the dynamics and logics of oil industry's global supply chain will critically contribute to Norway's abilities to facilitate the optimal utilisation of the country's own petroleum resources, as well as maintain its position as a large exporter of offshore related technology. The project answers directly to the call in its interest on how to develop a "stronger petroleum-related industrial development, a more rapid pace of innovation and increased competitiveness". Even though it is formally registered under theme 2, it is also relevant to theme 3 and 4.

As research on the Norwegian model shows, the country has been a successful case of the creation and upgrading of an entire industry of capable offshore suppliers. A mix of protectionism, state capital, incentives for skill formation and applied research, enabled Norwegian suppliers to stand off foreign competition and become successfully integrated in a global business structure and supply chains. From the early 1990s, the Norwegian industry and its supporting institutions have based their strategy on an open business environment. However, in recent years, the industry has faced an intense pressure to reduce costs because of lower oil prices. Concomitantly, many oil-producing nations, eager to promote their own economic development, have adopted policies aiming to capture or promote segments of the offshore supply chain within national boundaries. This uncertain, competitive and increasingly protectionist environment (particularly fostered by the United States' new administration) brings forth critical questions. Empirically, what is Norwegian suppliers business strategy governing their production supply-chain to continue moving up the OG global value chain? To what degree and in what way does taking part in technological challenging projects in key offshore markets abroad, affect the industry's innovative capabilities on project on the Norwegian continental shelf? Are there barriers in form of path dependency, technological standards or other forms of institutional and socio-economic structures that prevent or promote certain kind of technology and contractual relations in the supply chain? In policy terms, is the current Norwegian institutional setting that previously nurtured the industry still relevant and effective? Theoretically, can the Norwegian example help us understand how states and multinational companies (MNC) global supply chains play a role in promoting economic development in general and industry upgrading in particular?

We will seek to answer these questions by combining:
1) case studies of selected key supply firms operating in Norway;
2) case studies of recent field development projects in Norway, Brazil and U.S. GoM.;
3) a comparison of key policies on how to promote the OG industry in the three countries.
4) a survey on how Norwegian firms operate in foreign markets, with a special focus on Brazil and U.S. Gulf of Mexico (GoM);

With this, we intend to cast light on the under studied upstream OG global value chain and to understand the changing nature of industrial policies in a context in which domestic firms' capabilities are increasingly acquired through inter-firm relations that transcend national borders.

2. Background and Status of Knowledge

From the 1970s, with the discovery of large offshore oil fields on the Norwegian continental shelf, the country has been widely recognized as a successful case of economic development based on the exploration of natural resources. The multi-billion dollar sovereign fund built on oil royalties is a bright example. However, the development of a large, competent offshore supply and service industry was as important for Norway's economy.[1] By 2015, it employed between 140,000 and 200.000 people (Vatne, 2016, Hungnes et. al 2016). The consolidation of this *enabling sector* was crucial not only to make the extraction of oil viable but, by becoming Norway's largest export industry (apart from export of petroleum), it has been one of the pillars of Norwegian economy (Ville and Wicken, 2012; Wicken, 2016).

Up to the late 1980s, the industry's competence and capacities developed through a mix of protectionist incentives, such as local content requirements and clauses for technology transfer, state capital, stricter safety regulations, and policies to develop R&D capabilities in the private and public sector (Ryggvik, 2013, 2015). However, its successful evolution experienced a paradigm shift after most formal protectionist barriers were removed in 1994, due to Norway's enforcement of the European Economic Area Agreement with the European Union. Since then, foreign companies have been free to acquire Norwegian supply firms. American competitors have been keen in acquiring Norwegian companies to gain both domestic market share and access to key local subsea technology. In the 2000s, US companies such as National Oilwell Varco (NOV), FMC Technologies and Halliburton made major investments in Norway. Conversely, Norwegian suppliers acquired firms abroad and set up subsidiaries in all relevant regions for the offshore oil industry. As a result, by 2015, 40 % of the turnover of the Norwegian-based offshore supply industry came from international markets (Rystad Energy, 2016).

The pattern and logic of this internationalization have been driven by multiple factors. Market access and the search for new sources of innovation are the main drivers of expanding activities in the United States – for years one of the most important market for Norwegian suppliers. Houston is the biggest cluster of the oil industry in the U.S. and the laboratory for development of innovative technologies for the new deep-sea oil fields in the Gulf of Mexico (Priest, 2007). From the early 2000s, in a similar way, Norwegian suppliers have invested heavily in Brazil. The country's expansion of deep-water production since the 1990s is a natural market match with the expertise of Norwegian suppliers. Moreover, stringent local content requirements adopted during the 2000s favoured a strategy of "produce where you sell" with many suppliers opening new production facilities or establishing joint-ventures with Brazilian companies (Kasahara and Botelho, 2017). As the second largest foreign revenue source for Norwegian suppliers and large undeveloped oil resources, Brazil has become a strategic market.

Given the internationalization of the offshore supply industry one might expect a rather parallel technological development in the different oil and gas regions. This seems to be so when it comes to particular front edge technologies like drilling techniques, the use of seismic surveys etc. However, major differences in the architecture of large field development projects suggest that there are differences between offshore regions that cannot be explained by physical and geological conditions like water depths and volume and quality of resources alone. In the same manner as the Norwegian sector developed a certain "technological style" (Engen & Olsen 1997) linked to the use of large, fixed productions platform with hulls made of concrete, the Brazilian and the U.S. sector too have developed "styles" where elements of path dependency are apparent. The architecture of productions system for fields is the ultimate expression of offshore regions technological capabilities. The choice of platform concept (TLP, Spar, Semi-submersible, FPSO etc.), the connection to different kind of sub-sea installations, the use of storage on site, the link to pipeline network, the use of tie-back solutions and the way this kind of concepts is linked together through regulations and of contract relations, can represent important innovations in itself. While Brazil since the 1990s has based the development of deep-sea fields on the use of FPSOs (ships with storage capacity, but without drilling capacity), linked to advanced sup-sea installation trough flexible risers and complex umbilicals, the similar deep Gulf of Mexico activities have been run from large Spar-platforms and TLPs.[2]

[1] Our focus is on the segment defined by activities related to exploration, development, and production of oil offshore.

[2] Interestingly, the first FPSO was introduced in the U.S. Gulf of Mexico in 2012 in a field licensed to Petrobrás. The actual production unit was both owned and operated by the Norwegian FPSO-specialist BW Offshore. When Shell used a similar

Regarding Norway, after the last giant concrete platforms were built in the early 1990s, the Norwegian oil industry has been rather flexible in introducing new design for field developments. Norwegian oil companies and their suppliers have been important agents for spreading technologies as well as improving productivity on the Norwegian continental shelf by learning from international experience. For example, when Statoil, for the first time in Norway, chose a Spar-concept for the recent 37 billion NOK development of the Aasta Hansteen field, it was a technology that the company and related Norwegian suppliers had learned in the U.S. GoM. On the other hand, FPSOs have been in use on some Norwegian fields before. Nevertheless, when Statoil and other companies consider FPSOs as the main production concept for increased activities in the Arctic, it is a technology many Norwegian companies have learned to operate by their activities in Brazil.

A further global political economy trend that affects directly the Norwegian supply industry is the efforts of several states to capture shares of the offshore supply chain. The world has experienced in the last decade a proliferation of local content policies in the OG sector (Tordo et al, 2013). Brazil, for instance, is a paradigmatic case of this protectionist trend (Kasahara and Botelho, 2016; Botelho, Kasahara and Simas, 2017).

Although a highly complex and sophisticated global value chain (GVC), it is surprising the lack of an international literature on the organization of the offshore oil industry's supply chains.[3] More so, because the fragmented geographic distribution of the value chain discussed above makes it a perfect case for the GVC analytic framework pioneered by Gereffi (1994). However, there are important caveats to make when one seeks to apply the GVC perspective to the upstream OG sector. First, in analytical terms, the GVC literature has allocated a limited role for the state in shaping or fostering inter-firm relations. Only recently, there have been initiatives to integrate the GVC framework with policy debates about the role of the state in industrialization processes (Milberg et al. 2014). A second limitation refers to the hierarchic organization of the nodes within the chain. At one extreme, lead firms would tend to retain the lion's share of profits through controlling value-added activities such as branding, design, R&D, and distribution channels, while suppliers would specialize in standardized mass produced components and parts with very thin profit margins.

However, as oil companies have practically de-verticalized all their supply chain during the last two decades, the relations between the diverse actors are hard pressed to be described by existing models of GVC governance (Gereffi et al. 2005), as lead firms and top suppliers exhibit dynamics that do not fit its analytic framework. Although oil companies undoubtedly remain the lead firms of the chain, integrating equipment and services to explore and extract oil, they often rely on the capabilities of top suppliers able to take on large *engineering, procurement, and construction* (EPC) contracts. Offshore OG suppliers present also some important differences in comparison to others industries producing commodities for mass markets. One reason is that they provide highly customized equipment and services according to geophysical characteristics of fields and wells. Another important aspect is the rent nature of the sector. Owners of large oil fields (companies and states) are in a position to capture larger rents from revenues in comparison to other types of commodities. This has also influenced relations between oil companies and their contractors. During the long and recent boom (2004-2014), several top suppliers succeeded in capturing parts of that rent, resulting in higher cost increases in the offshore oil sector compared to other industries in the period. Correspondingly, falling oil prices, led oil companies to again rearrange their relationship to the supply and service industry. Thus, the pressure is on reducing extraction costs to maintain rents from falling, making top suppliers strategic nodes of the value chain.

Today, particularly in offshore deep-water operations, oil companies are completely dependent on a few top suppliers who control the technology and expertise to explore and extract oil, blurring traditional hierarchies between lead firms and top tier suppliers.[4] Until recently, markets for subsea

solution on a field in 2016, it also used the same type of contract in which both operation of a production unit and the unit itself were outsourced.

[3] For exceptions, see Bridge (2008) and Beyazak-Odemis (2016).

[4] This leads to a tense relationship between oil companies and their top suppliers. One clear conflict is over the technical specifications regarding particular projects. While oil companies push for standardization and technical guidelines that could be transferred to other companies and promote competition, top suppliers push for proprietary designs and products that are harder to replicate. In Norway, this dynamic is exemplified by the historical relationship between Statoil and the main engineering Norwegian company Aker (Ryggvik, 2015).

activities had been divided between construction of installations (Christmas trees, manifolds, installations and maintenance), their operations (supply ships and advanced ROVs), and wells services (drilling, logging and other activities to optimization of production). However, with the recent merger wave (TechnipFMC and Schlumberger-Cameron) the largest top suppliers have been aiming to increase economies of scope and able to take contracts covering a large part of the value chain, including those with higher valued-added and margins. For example, since 2015, the oil service company Schlumberger, with over 100.000 employees worldwide, has become larger than the leading major oil company Exxon Mobile. In the same year, Aker Solutions, the largest Norwegian supply firm had around 16.000, Since having a structure and size that could match the top suppliers was considered to be essential, there were constant rumors of potential mergers or takeovers .

While parts of the past relationship between oil companies and their main offshore suppliers have been previously described and analyzed in different national settings (Ryggvik, 2013; Priest, 2016), there has been to our knowledge no in-depth academic study that looks at the relationship between top suppliers and how these top suppliers organize their own global supply chains. More important little is known about how Norwegian top suppliers organize their supply chains and how their internationalization proceeds, as well as how pressures for cost reduction from lower oil prices affect the multitude of Norwegian small and medium-sized enterprises (SMEs) that make up important segments of the chain's lower tiers. Some top suppliers, for instance, seem to have been adopting traditional strategies, such as offshoring production of medium and low added-value components.[5]

3. Approaches, hypotheses and choice of method

One important literature that drives this project is the theory of the firm. The study of the evolution of MNCs has roots in the business history tradition of the American historian Alfred Chandler (Chandler 1962, 1977, 1990). Chandler described the integrated, diversified multinational firms as the core innovative, modernising force in society. With their size and advanced organisational structures, these companies could exploit the benefit of scale and scope. In a complementary manner, transaction cost analysis (Coase 1937, Williamson 1975) stated that the right balance between in-house production and outsourcing to contractors and sub-suppliers could be calculated.

The massive growth in trade and foreign direct investment (FDI) from the mid- 1980s spawned a vast literature that discussed the development of MNCs in relation to the emerging concept of globalization (Porter 1985 and 1990. Reich 1990, Omahe 1990, Dunning 1993 etc.). This literature tended to downplay the significance of ownership: countries and regions should concentrate on their comparative advantage. Growth and innovation were to be achieved by increasing workers' skills and strengthening engineers' competence. Investments in education, research and effective infrastructure were key policy instruments. As MNC intra-firm trade became increasingly a larger part of world exports, this was seen as a sign of more globalized products as well as more globalized, integrated organizational structures.

Yet, after more than 25 years with globalization as the main signpost for development, several counter tendencies have emerged. Keynesian criticism attacked the neoliberal framework of institutions promoting free trade and capital movements, such as the IMF and the Word Bank (Stigliz 2003, Skidelsky 2009). Part of the political right has garnered popular support by opposing globalization, with a particular focus on immigration. However, the kind of extreme globalization announced in the early 1990s did not materialize[6], despite trade and FDI being larger in a historical perspective. Competing perspectives seek to make sense of the nature and dynamics of GVCs to explain these trends.(UNCTAD 2013, Evenet & Friz 2015, Taglioni & Winkler 2016). Although industrial products still contain parts and components from several parts of the world, one observes a trend for MNCs to build up fully-fledged regionally based supply chains, with headquarters relinquishing control where it matters: quality standards, continuous learning and innovation. As some domestic suppliers upgrade and carry out applied research, learning and transfer of knowledge become a multi-centric exercise orchestrated by

[5] Aker Solutions – the main Norwegian supplier of subsea equipment – uses 60% of foreign suppliers, mostly from other European countries, in its factory in Tranby, Norway. Interview with the factory's Production Manager in March 30, 2017.

[6]Since 2010 most types of international trade have either been stagnant or falling (Evenet & Riz 2015. Livesey 2017). The same has been the case with FDI. Measured in percentage of total global GDP, FDI is lower than in the late 1990s. Further, the share of export in in cross-border supply chains has been stagnant since the 2008 financial crisis. Finally, in recent years, return on equity has been smaller for MNC than for domestic firms (Economist 2017).

MNCs. Therefore, a central question for the project will be to what degree top suppliers in the oil sector can be major agents for upgrading domestic suppliers. Following that, how important is national ownership, location of headquarters and R & D-functions in this?

In the project, we will adopt supply chain-based perspectives found in recent studies about the internationalization of manufacturing in the auto, capital goods, and electronics as alternative hypothesis of the potential trajectory of the Norwegian offshore supply industry. Seeing development in the oil industry in the light of recent development in other industries can be illuminating. Looking at the internationalization of the German auto and capital good industries in China, Herrigel (2013; 2014; 2015) analyses the organizational implications of the "produce where you sell" adopted by many German companies. Besides the fast-growing demand from emerging markets, such as China, being a strong incentive to produce locally, the intense competition as well as the need to adapt products to local preferences and regulatory standards make local production a more rational strategy than exports. For German manufacturers that meant establishing a close relationship with local suppliers and provincial authorities in order to upgrade their technical capabilities. The interesting find from Herrigel's work is the establishment of a corporate production system based on mutual and continuous learning between German companies and their Chinese suppliers. As local suppliers increased their capabilities, they became active partners in productive process, earning an expanded role in designing and manufacturing of products. Through the adoption of managerial systems that valued the inputs of local suppliers, German headquarters and subsidiaries elsewhere could more easily incorporate improvements and innovations made in China. Consequently, local production and suppliers turned to be important sources for innovation and the acquisition of new comparative advantages by German companies.

There are other contrasting perspectives, like Kwon and Kim (2017), "bring your supply chain along". Based on the experience of South Korean auto and electronics manufacturers, also in China, the authors claim that the strategy focuses on bringing well-known sub-suppliers with them when trying to penetrate the Chinese market. Considering these contrasting accounts, a guiding question of the project is whether and to what degree Norwegian offshore suppliers' internationalization strategy and organization of sub-suppliers is evolving towards the "produce where you sell" model or to the 'bring your supply chain along" one. Parallel, and as important for development on the Norwegian continental shelf, is to what degree suppliers with foreign ownership and headquarters are placed between this dichotomy.

Considering the debate above, this project aims to throw light on unveiling how the relationship between business strategies, state policies and institutions affect corporate decisions about the organization and governance of supply chains. Whereas on one hand, companies have their own internal reasons to organize the supply chains (e.g. cost reduction, reliability, better product and technological development); on the other, policies both at home and in host countries appear to play an important role in these decisions.

This general question allows us to formulate four sets of hypothesis:

1) What factors shape OG top suppliers' strategic choices for internationalizing (FDI)?
    a. New product development and process learning possibilities?
    b. Size or strategic location of the market?
    c. National policies and regulations (including sub-supplier qualification programs)?
2) How do such choices shape the supply chain architecture and governance at home and abroad?
    a. How do top suppliers and sub-suppliers' internationalization strategies converge?
    b. To what extent and how do sub-suppliers at home and abroad contribute for the value creation of top suppliers?
    c. How different Norwegian top suppliers are from their foreign competitors in organizing their supply chains?
3) What are the consequences of different supply chain architectures for technological transfer and innovation?
    a. Is one strategy more favorable to technological transfer and innovation than others?
    b. To what extent are Norwegian suppliers benefiting from internationalization of their supply chains to learn from abroad?
    c. What could be done to improve Norwegian firms' supply chain management?

4) What do the nationality of ownership, and geographical location of headquarters and R& D facilities mean in this new environment?
    a. Are we still moving towards a situation in which MNCs in the oil sector have become neutral technological "upgraders" in all the localities they operate, independent of origin?
    b. Are we experiencing the rise of a new phase of protectionism in which national origins and location have become important again?

In order to answer these questions the project is organized in the following work packages (WP):

WP1: The internationalization of Norwegian-based lead firms in comparative perspective

In this work package, we will conduct an in-depth study of how six of the largest Norwegian offshore supply and service companies have built global supply chains. Preliminarily, we have chosen Aker Solution, Subsea 7, PGS, Technip, FMC, NOV and Seadrill as cases. They are dominant players on the Norwegian shelf, as well as large exporters, and hold manufacturing facilities worldwide. However, they represent at the same time different forms of "Norwegianness" when factors such as ownership, headquarter functions, import/export, and localization of research are taken into account. Typically, when Technip (Norwegian subsidiary with little exports) and FMC (Norwegian subsidiary with large exports) merged in 2016, the Norwegian part became less apparent.

First, we will review the development of the above companies since the early 1990s, building on resources from the NFR funded SIVAC-project and secondary sources. The main empirical focus will be on development after the 2014 fall in oil prices. Second, we will interview former and current supply chain managers and strategy executives in the companies to characterize the evolution of their domestic and foreign supply chains and to identify strategic suppliers in their chains in Norway, U.S. and Brazil. In parallel, we will compare supply chain dynamics from companies whose origins are from a different national economy (e.g. Schlumberger, GE and Haliburton).

WP2: Field-design and transfer of technology

In this WP, we do an in-depth study of recent and on-going field-development projects on Norway, Brazil and U.S. GoM. In Norway, we will study the Aasta Hansteen field and the plans to develop the Johan Castberg-field in the Barents Sea. In Brazil, we will study the development of the ultra-deep Libra-field and in the United States, Shell's Stones field. In all cases, the focus will be on uncovering the sociology, politics and economic factors underlying critical technological choices. A central question will be to what degree the chosen concept is based on experiences elsewhere or represents innovative solutions. In a study of all main involved contractors, we will focus on the nationality of companies, involved personnel and to what degree the relevant competence can be traced to knowledge developed in other offshore regions. Empirical information will be based on public available information as well as interviews with technical staff of oil companies as well as their suppliers.

WP3: The evolution of Norwegian-based sub-suppliers in comparative perspective

The intention of this WP is to identify the relationship between Norwegian top-suppliers, and local suppliers in different national settings. We draw on inputs and evidences from WP1 and WP2. The main empirical work will be to study Norwegian sub-suppliers considered strategic by top-suppliers. We are particularly interested in understanding how these sub-suppliers are integrated in the production systems of top-suppliers and to what extent they contribute for the development of new products and technologies. In addition to the analysis of Norwegian sub-suppliers, we extend our scope to include selected sub-suppliers also from U.S. and Brazil in order to identify the role of different national settings.

WP4: Survey evidences of supply chain relationships in different national settings

The main goal of this WP is to test some of the patterns and mechanisms of internationalization, technological transfer, and organization of the supply chain identified by case studies conducted in the previous WPs. The survey will be conducted in Norway, Brazil, and the US and will oversample

Norwegian companies in the two last countries. With the survey, we aim to identify whether key mechanisms identified on case studies are examples of either a general pattern or deviant cases in Norway. Moreover, due to the cross-country design of the survey, we want to identify whether how Norwegian companies operate in foreign markets in comparison to local competitors. For example, if Norwegian companies replicate supply chain organization and inter-firms relations in Brazil and the US or adopt different practices. In addition, the survey will be identify to what extent knowledge produced from operations abroad are relevant for operations in Norway. Lastly, we will be able to test in a broader sample the importance of ownership and national settings on inter-firm cooperation, technological transfer, and innovation. One important practical challenge for the realization of such surveys is the identification of the universe of companies to be sampled. While project members already have directories of suppliers and sub-suppliers of the OG sector for Brazil and Norway, it will require more work to define the list of companies in the United States. Another practical challenge is the identification of appropriate respondents within the companies. As many of our questions relate to both strategic, but also managerial aspects, in relative large companies we might have to look for more than one respondent (e.g. directors and supply managers). We will hire an international research company with experience in all three countries to conduct the formalized interviews. We have contacted IPSOS, a well-established survey company, about the feasibility and the budget of the planned survey with a positive response.

Relevance and benefit to society

The project will shed light in to the development of an industry of great importance for the Norwegian society. We think a new and better understanding of the dynamic of how companies manoeuvers successfully in global value chains can be helpful both for companies themselves and for government policy makers. By studying the effects of technological and institutional upgrading as a consequence of the MNCs tendency to localize parts of supply chains, we also think our work can be of great value for local industries and policy makers in newly industrialized countries like Brazil and Mexico as well as developing countries with large oil resources. With our highly international and experienced team also have aspirations to develop general knowledge that can be relevant on the international research front. **Environmental impact:** Apart from the traveling that will take place the project does not expect to have positive (or negative) effects on environment. However, by using research assistants to do a lot of the collection of data and local firms to conducts surveys, we are limiting traveling to some degree. **Ethical perspectives**: The project will follow the guidelines of all Privacy Ombudsman for Research (NSD) and have the prior approval of the Ethical Committees of all involved partners. **Gender issues:** The project team recognize that the gender unbalance in its composition and will try to address that in the composition of the advisory committee. Gender consideration will also be central during the selection of PhD students.

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