

Gullfaks - the first Norwegian oil field developed and operated by Norwegian companies

Hildegunn Kyvik Nordås

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1 Introduction¹ – the Gullfaks field²

This paper analyzes the role of producer services in the categories engineering, maritime services and non-maritime services in the exploration, development and operation phases of the Gullfaks oil field in the North Sea. The purpose of the paper is to study the market structure of the Norwegian offshore market for oil-related services. We focus on the extent of competition in the various segments of the market, the Norwegian market share and the nature of vertical linkages between oil companies and the offshore industry, focusing on services. We finally discuss how the producer service sectors have contributed to technological developments during the Gullfaks development.

It has been a stated objective from the establishment of oil production in Norway to develop a Norwegian petroleum sector, including oil companies and an offshore industry. Gullfaks was the first field where Norwegian companies were responsible for the entire life cycle of the field from exploration to production. It is also the first field where Norwegian companies only have been given owner interests.³ Hence, Gullfaks represented a milestone in Norway's development as a petroleum producer, given the objective of fostering a national petroleum industry. Statoil did, however, have an agreement with Esso for technical assistance during the exploration phase. This agreement was terminated in 1981. A new agreement for technical assistance was entered with Conoco Norway during the development and operational phase.

The Gullfaks field is located in block 34/10 on the Norwegian continental shelf. The license was awarded to Statoil in 1978. Statoil became the operator in 1981 with an 85 percent share in the license. The remaining 15 percent were awarded to Norsk Hydro (9 percent) and Saga Petroleum (6 percent), adding up to 100 percent Norwegian ownership.

In 1984 the Norwegian parliament decided to divide Statoil's participation in licenses on the Norwegian shelf into two parts, the company's own financial involvement and the state's direct financial interest. In 1985, 73 percentage points of Statoil's share in the Gullfaks license were transferred to the state's direct financial interest. Statoil administers the state's direct financial interest both in the Gullfaks field and in the other fields where the state has direct financial interests.⁴ In practice this means that a part of Statoil's gross revenues from petroleum production is automatically

¹ I am grateful to Ola Kvaløy for research assistance, The Norwegian Research Council for financial support under the program "Næring, Finans og Marked," and Statoil, Aker, and the Ministry of Oil and Energy for useful information and comments.

² If not otherwise stated the facts referred in this section is taken from Fact Sheet The Norwegian Continental Shelf, various issues, issued by the Royal Ministry of Petroleum and Energy.

³ The objective of securing a significant part of petroleum activities for Norwegian companies was combined with the aim of ensuring participation from the most competent foreign oil companies. Apart from Gullfaks and its satellites, the only other field with Norwegian participation only is the Varg field, a small oil field.

⁴ New regulations introduced in 1985 required that Statoil should hold at least 50 percent in all new licenses, including the Norwegian state's direct financial interests. The new regulations did not affect existing licenses, however. At present (2000) there is an ongoing debate about privatization of Statoil. The role of the state's direct financial interests is one of the key issues that needs to be addressed in this process.

transferred to the state, and that a corresponding share of Statoil's expenses is covered by the state.

The initially estimated recoverable reserves at Gullfaks were 210 million Sm³ of oil, 14 billion Sm³ of dry gas and 2 million tones of condensate. Reserves are spread over a 50km² area, about 2000m under the seabed. The recoverable reserves have been upgraded several times since the first estimate and stood at 316 million Sm³ of oil, 23 billion Sm³ of dry gas and 2.4 million tones of condensate in 1998. Upgrading is mainly due to improved extraction technology that has increased the recovery rate. The most recent estimate also includes two marginal fields that have been linked to Gullfaks during the mid 1990s.⁵

The Gullfaks field was developed in two phases. The first phase consists of two platforms with concrete gravity bases, Gullfaks A and B. The platforms have a similar technology and design as the Statfjord platforms. These were developed before the Gullfaks platforms by Mobil who developed the Statfjord field and operated it for an agreed period of time after which operation was transferred to Statoil. Production from the Gullfaks A platform came on stream in late 1986, 7 months before planned, while production from the B platform started in early 1988, 9 months before planned. The Gullfaks A platform is an integrated drilling, processing, storage and accommodation platform, while the B platform is a simpler drilling and wellhead platform. Gullfaks A is positioned at a sea depth of 130 meters and had an initial production capacity of 39 000 Sm³ or 245 000 barrels of oil per day.

Phase 2 of the Gullfaks project involved the construction and installation of the Gullfaks C platform. It is a condeep platform of the same type as Gullfaks A, but since it is positioned at a depth of 220 meters, its concrete substructure is much larger. Phase 2 came on stream in November 1989. The Gullfaks C platform contains a control center for aircraft and vessel traffic to the entire Gullfaks field.

Combined production capacity from the three platforms is about 630 000 barrels of oil per day. The Gullfaks field contains about 100 wells, including wells for injection of water and gas to keep up the pressure in the reservoir. The three platforms are interconnected through pipelines. A number of subsea-completed wells, including new fields discovered in the area close to Gullfaks, have also been connected to the three platforms. Three satellite fields, Gullfaks South, Rimfaks and Gullveig, have been developed recently using state of the art subsea technology. Oil from these satellites are processed at the Gullfaks A platform, while the Tordis field is linked to the Gullfaks C platform. In this way storage and processing capacity at the three Gullfaks platforms have been utilized even as production from the Gullfaks field itself has peaked.

The oil from the Gullfaks field is stored in the gravity bases of the three platforms and loaded on to tankers in the field via loading buoys. The gas is piped to Kårstø through the Statpipe system from the Statfjord field. The wet gas is separated at Kårstø while the dry gas is piped on via Ekofisk to Emden in the Netherlands.

⁵ Gullfaks West is linked to Gullfaks B through two long horizontal wells, and the Lunde field is linked to Gullfaks C through horizontal wells.

The rest of the paper is organized as follows. Section 2 gives a broad overview of the market structure of the offshore and oil-related services sector for supply to the Gullfaks field. The data is broken down to three phases of the project, the exploration phase, the development phase and the operational phase. Section 3 analyzes the market for producer services in more detail. Four categories, engineering, maritime services, non-maritime services and other services are examined. The data is taken from a database compiled by the Ministry of Oil and Energy, the PI-base. These data are supplemented by the annual reports of the companies involved, interviews and other sources of information. Section 4 discusses vertical relations between the operator, contractors and subcontractors. Section 5 presents findings on technological developments during the Gullfaks field development, while section 6 summarizes and concludes.

2 The structure of the Gullfaks market – an overview

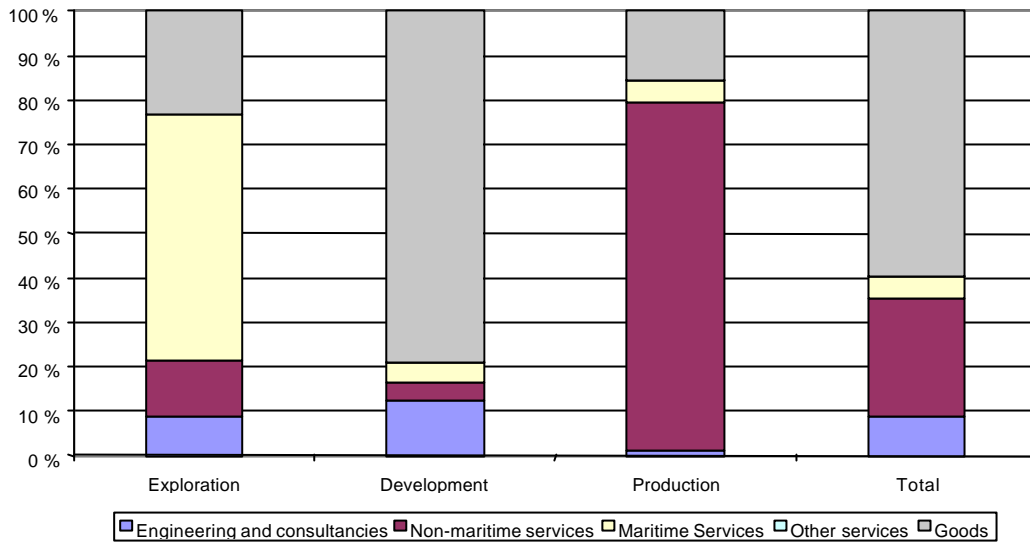
2.1 *The size of the market and market segments*

The total value of contracts awarded for the Gullfaks field in current prices registered in the PI database, which is used for the analysis in this section, is about NOK 40 billion. Of these 28 billion were spent on the development phase, 16 billion on the operational phase and 168 million on exploration. The 28 billion recorded during the development phase compare to NOK 77 billion, measured in 1997 prices, estimated by the Royal Ministry of Oil and Energy (1998) as the total investment cost on the Gullfaks field. The difference is partly due to the participating oil companies' own inputs in the project, which are included in the Ministry's estimates, but not in the PI base, and partly due to inflation. There are, however, probably also gaps in the PI database. Still, the database is the most comprehensive source available for data on transactions between the oil companies and the supply industry, and we therefore use it as our major source of data.

The relative cost of the three phases depends in general on the extraction technology, the organization of the project, and at what point in time accumulated costs are measured. The oil company can for example choose between investing in drilling equipment on the platform or rent a rig for drilling purposes. The first alternative gives high costs during the development phase and lower costs during the operation phase, while the second alternative yields the opposite time profile of costs. Statoil chose the first alternative with drilling equipment on the platforms, which yields high fixed costs and thus a high relative share of total costs during the development phase.

Figure 1 shows the composition of inputs during the three phases of the Gullfaks project, distributed on four categories of services (engineering, maritime services, non-maritime services and other services) and an aggregate category for all goods. One of the criteria for classifying a service as maritime or non-maritime is whether it is provided from vessels or from rigs or onshore. Maritime services are provided from vessels and non-maritime services from rigs or they are produced onshore. Maritime services contain the subgroups: personnel transport, services from supply vessels, drilling vessels, diving services, cranebarges, flotels, barges/tungs, seismic survey vessels, soil sampling and pipelaying barges. Non-maritime services contain the subgroups: drilling contractors, mud engineering, cementing, testing/logging, well services, catering, and maintenance.

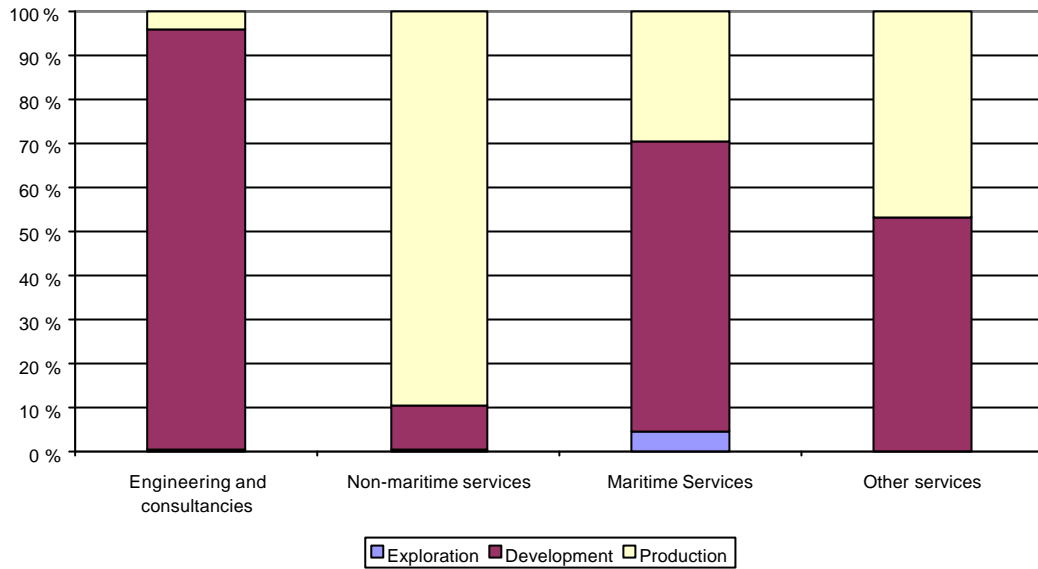
Figure 1: Cost shares, the Gullfaks field.



Source: the PI base

The figure shows that each phase has its distinct composition of expenditure. Goods account for almost 80 percent of total expenditure during the development phase, while services account for almost 80 percent of total expenditure during the exploration phase and more than 80 percent during the operation phase. During the exploration phase maritime services account for the largest expenditure share, while non-maritime services account for the largest expenditure share during the operation phase. Nevertheless, for all service categories except non-maritime services, the development phase constitutes the largest market in absolute terms as shown in figure 2 below. This partly reflects that the project was still early in its life-span in 1994 which is the last year of data. Thus, the relative importance of the operational phase will increase over time. Nevertheless, figure 2 provides a representative picture of the market for petroleum-related services during the first three decades of oil production in Norway.

Figure 2: Service supply by phase



Source: the PI base

It is probably fair to say that a duopoly had developed in the Norwegian market for large-scale offshore investment projects during the 1980s. The two dominant companies were Aker and Kværner.⁶ The 5 largest contracts for each of the 3 platform projects during the development phase are presented in table 1. Note that all contracts included in the table were awarded to either Aker or Kværner, or companies that later became part of Aker.⁷ As for the Gullfaks C platform, all the five largest contracts were awarded to Aker.

⁶ See also tables 4 and 5 below.

⁷ Norwegian Contractors is a company within the Aker Group, fully owned since 1988, and Norwegian Petroleum Consultants merged with Aker Engineering in 1991. Moss Rosenberg Verft belongs to the Kværner Group.

Table 1: The 5 largest contractors for the Gullfaks platforms

Supplier	Item
<u>Gullfaks A</u>	
Norwegian Contractors	Gravity base and shaft (GBS) fabrication
Aker Stord	Module support frame fabrication, outfitting and hook up
Moss Rosenberg Verft	GBS main mechanical outfitting
Kværner Installasjon	Offshore hookup
Aker Værdal	Main control power module
<u>Gullfaks B</u>	
Norwegian Contractors	Engineering, construction, deck mating, tow and installation of offshore location of the GBS
Moss Rosenberg Verft	Fabrication contract for the module support frame and hook up
Norwegian Petroleum Consultants /Bethel	Project service contract
Moss Rosenberg Verft	Offshore hook up and assistance in commissioning
Aker Engineering	Detail engineering, deck and modules
<u>Gullfaks C</u>	
Norwegian Contractors	GBS, EPC contract
Aker Stord	At shore hook up
Aker Contracting	GBS main outfitting, EPC contract
Norwegian Petroleum Consultants	Head consultant project assistance (PSC)
Aker Stord	Offshore hook up and commissioning

Source: The Norwegian Ministry of Oil and Energy (The PI base).

The gravity base and shaft have a weight and volume that made transport over long distances difficult, and therefore had to be built as close to the oil fields as possible. This gave a natural protection to companies located at the North Sea rim, but not necessarily to Norwegian companies. However, the fact that Aker Stord did the completion and hook-up of three platforms for the British sector during the late 1970s indicates that the Norwegian offshore sector was reasonably competitive at the time. Aker Stord's major advantage is its deep-water site (Myklebust 1994).⁸

A comparison of the nature of service contracts to the three platforms shows an interesting development in the division of labor between the oil companies and the major contractors. This will be discussed in more detail in section 4. For now we note that none of the 5 largest contracts to the Gullfaks A platform was on services, two of the 5 largest contracts were for engineering services on the Gullfaks B platform, while one of the largest contracts for the C platform was an engineering contract. First, this reflects a trend towards outsourcing major engineering services such as concept evaluation, project management and pre-engineering. These functions were undertaken within the Statoil organization with assistance from the technical partners Esso and Conoco for the Gullfaks A platform. A different way of organizing the project was introduced with the B and C platforms where project management was outsourced to an external firm. Norwegian Petroleum Consultants (NPC) was awarded the management contract in cooperation with the American engineering firm Bechtel for the B platform, while NPC did the job on its own on the C platform project. Second, the fact that project management contracts were among

⁸ Myklebust (1994) provides a number of anecdotes and information about the difficulties during restructuring from a shipyard to an offshore company at Stord Verft, and how the difficulties were overcome and resolved.

the 5 largest contracts for the project indicates the scale of the task and the costs of transactions and coordination during the projects.

We now turn to a presentation of data on supply to the Gullfaks field based on the PI base. Table 2 shows the distribution of contracts measured by the number of contracts.

Table 2: Number of contracts

	Exploration	Development	Operation	Total
Engineering	5	124	39	168
Non-maritime services	4	98	109	211
Maritime services	7	44	18	69
Other services	0	3	5	8
Goods	6	1005	235	1246
Total	22	1274	406	1702

The number of contracts awarded during each phase and to each category largely reflects the relative level of expenditure during each phase and category as depicted in figures 1 and 2, although the average value of contracts varies as shown in table 3.

Table 3: Average value of contracts (NOK mill.)

	Exploration	Development	Operation	Total
Engineering	2.9	28.1	4.0	21.8
Non-maritime services	4.9	11.2	88.7	51.1
Maritime services	12.6	29.6	32.5	28.6
Other services	0	4.6	2.5	3.3
Goods	6.1	22.2	8.3	19.5
Total	7.0	22.2	29.4	23.7

The value of contracts varies not only among the categories, it also varies a lot within the categories. For all categories the median contract value is much smaller than the average contract value. Non-maritime services, for example, have a median contract value of only NOK 4.2 million compared to the average of 51.1 million. This reflects the fact that there are a few very large contracts complemented by a large number of smaller contracts for adjustments and supplementary work to major contracts. There are also a large number of small contracts for specialized services provided by niche companies.

2.2 Market concentration and competition

In this section we take a closer look at competition in the service market for the Gullfaks field. The indicators chosen are:

- i) The degree of concentration in the market measured by the market share of the 5 largest and 2 largest suppliers;
- ii) The Herfindahl index;
- iii) The number of bidders per contract and
- iv) The Norwegian market share.

We analyze these figures for the Gullfaks field as a whole and for each service category.

Table 4: Market share of 5 and 2 largest companies and Herfindahl Index

	Exploration	Development	Operation	Total
Engineering	100, 68 0.38	90, 84 0.65	68, 49 0.14	87, 81 0.61
Non-maritime services	100, 78 0.41	46, 25 0.06	91, 78 0.32	83, 71 0.26
Maritime services	100, 97 0.87	63, 30 0.10	91, 72 0.39	53, 28 0.08

Market share (percentage) for the 5 and 2 largest companies respectively is given in the upper row of each cell, the Herfindahl Index in the lower row.

All indicators of concentration show that engineering is clearly the most concentrated service sector, while exploration is the most concentrated phase. A relatively high market share of the 2 largest companies combined with a relatively low Herfindahl Index reflects a market structure with a few leading firms and a large number of niche producers. This is a market characteristic of non-maritime services where well services, testing and logging contain a large number of niche producers. For the Gullfaks field as a whole, one offshore company, Aker, dominates with a market share of 33 percent, while Kværner's market share was 12 percent of all contracts registered in the PI database for the Gullfaks field. Aker dominates engineering, while the two have more equal market shares in non-maritime services and none of them dominates maritime services. Also in the markets for engineering and maritime services there is a large and diversified underwood of smaller niche firms servicing the petroleum sector. Table 5 identifies the two largest suppliers in terms of market share by category and phase.

Table 5: Dominant companies by sector and phase

	Exploration	Development	Operation	Total
Engineering	Aker, Kværner	Aker, Norwegian Rig Consultants	Aker, Grønner Offshore	Aker, Norwegian Rig Consultants
Non-maritime services	Eastman B.J. Huges	Sedgwick, Schlumberger	Aker, Kværner	Aker, Kværner
Maritime services	Schlumberger, Stolt Nielsen	Aker, Inocean	Rockwater Coflexip	Rockwater, Aker

In order to get an impression of the competitiveness of the markets, table 6 presents the average number of bidders per contract:

Table 6: Average number of bidders per contract

	Exploration	Development	Operation	Total
Engineering	1.4	2.0	1.7	1.9
Non-maritime services	3.5	2.7	2.3	2.5
Maritime services	4.4	3.0	2.1	2.9
Other services	0	2.7	2.2	2.4
Goods	2.7	2.9	2.5	2.8
Total	3.0	2.8	2.3	

This table suggests that there is little competition on the Norwegian offshore market, particularly in engineering services, which have less than two bidders per contract on average. However, the number of bidders per contract may underestimate the extent of competition in the offshore market for at least three reasons. First, our data may underestimate the extent of competition due to the fact that Statoil's contracts with subcontractors are some times in the form of frame agreements. There may thus be little or no competition on single contracts covered by the frame agreement, while there may be fierce competition for the frame agreement. Second, a number of contracts entail options for future deliveries such that absence of competition on a particular contract may be due to the fact that an option is executed. Third, a number of small contracts is supplementary to larger contracts and it is often most cost effective to place such orders with the same company who was awarded the main contract.

A factor that does limit competition is the cost of bidding on a contract. Furthermore, the cost for the individual bidder may depend on experience from previous deliveries and investments made in assets needed to deliver a certain quality required by the oil company. Thus, there may be both static barriers to entry and dynamic learning effects from an established customer relationship that over time have erected barriers to entry in segments of the market.

With these qualifications in mind, the exploration phase appears to be the most competitive of the three phases, while maritime services appear to be the most competitive producer service sector. The degree of competition is largely a function of the size of the market and the tradability of the inputs in question. The Norwegian Ministry of Oil and Energy emphasizes that international competitive bidding should be the guiding principle for awarding contracts. However, out of a total of 168 engineering contracts only 32 had foreign bidders, or an average of 0.2 foreign bidders per contract. The corresponding figures for non-maritime services were that out of 211 contracts, there were foreign bidders on 58, and the average number of foreign bidders per contract was 0.4. Finally, for maritime services 41 out of 68 tenders had foreign bidders, and an average of 1.13 foreign bidders per contract. These figures underestimate foreign participation since Norwegian subsidiaries of multinational firms are counted as Norwegian in the PI base as long as they produce the goods or services in Norway. The figures nevertheless suggest that direct investment is the preferred mode of servicing the Norwegian market for foreign companies. This is probably due to both Norwegian market regulation and the nature of the services. Norwegian market regulation promoted Norwegian companies. For example, before Norway entered the European Economic Area in 1995, one of the criteria for awarding a new license in Norwegian waters was the degree to which the applicant had made use of Norwegian goods and services in Norway and abroad. For R&D expenditure the involvement of Norwegian participants was stated more explicitly. The operating companies were obliged to ensure that at least 50 percent of the total expenditure on R&D covered by the production license would be spent in Norway and in cooperation with Norwegian contractors.

Table 7: Norwegian market share percent of total purchases

	Exploration	Development	Operation	Total
Engineering	100	85	57	84
Non-maritime services	56	68	93	91
Maritime services	89	61	49	59
Other services	-	100	78	89
Goods	67	75	43	72
Total	82	75	83	78

The Norwegian market share is relatively high at 78 percent on average for the project. The service sector that appears to be most open to international trade is maritime services. The most tradable inputs, goods and maritime services, have the lowest Norwegian market share. These inputs are less field-specific and less integrated with the construction process than for example engineering. Thus, seismic surveys, drilling from mobile vessels or rigs and transport constitute international markets of largely standardized services, or services characterized by flexible customization. Recall from table 5 that these services also have the highest number of bidders per contract and thus appear to be the most competitive markets. It is interesting to note that the lowest Norwegian market share is found in the market segment where Norwegian firms show the largest export performance (maritime services)⁹. This indicates that the industry is characterized by intra-industry trade either because of firms specializing in different niches of the market, or because of the need for geographical diversification due to swings in demand; or a combination of both these factors. Engineering is not much traded because engineering services are undertaken in close relation to the construction and operation activity and often needs to be performed at the construction site or the operation site.

We have seen in section 2.2 that foreign firms have not been particularly active in bidding for contracts on oil-related services from abroad. Their participation in the market has mainly been through their Norwegian affiliates, and they have worked in cooperation with the Norwegian supply firms, and in some cases by entering joint ventures with Norwegian companies.

3 Producer services

In this section we will analyze the market structure of inputs for each producer service category within each phase of the project in more detail. We use the information presented in tables 2-7, supplemented by information from interviews with key personnel in Statoil and Aker. The analysis focuses on market structure and contractual relations between the oil company and the supply industry.

3.1 The exploration phase

As seen from figure 1, services account for a large share of total expenditure during the exploration phase. Maritime services, e.g., services provided from vessels or aircraft, are by far the most important accounting for close to 50 percent of total exploration costs. Within this category seismic shooting and analysis is the most important. The other subgroups are soil sampling and surveying. Taking a closer look at this market reveals that the leading multinational service firms dominate the list of

⁹ See Nordås and Kvaløy (2000) for a discussion.

bidders. Seismic shooting, processing and analysis of seismic data are among the most research-intensive activities in the petroleum sector. Furthermore, providing such services requires large investments in vessels and computer hardware and software. There are therefore significant economies of scale in this business, which could explain the larger concentration in this market than in the non-maritime service market, and the absence of Norwegian firms in the market at this early stage of Norwegian oil production.¹⁰

Maritime services are followed by non-maritime services in relative market size during the exploration phase. Non-maritime services include exploration drilling, testing, logging, cementing, other well services and maintenance and repairs. This market is the one with the lowest Norwegian market share as can be seen from table 7. The contracts are relatively small ranging from NOK 2 to 11 million and 5 different firms were awarded contracts. The market for exploration drilling is global. A number of Norwegian shipping companies are important players in the world market as well as in the North Sea. Well services are research-intensive and highly specialized activities dominated by a relatively small number of multinational groups. These also dominate the Norwegian market, albeit through their Norwegian affiliates.

Engineering services are not important in terms of relative expenditure during the exploration phase. Contracts are relatively small, between NOK 1 and 5 million. All engineering contracts registered under the exploration phase relate to concept evaluation studies and R&D.

3.2 The development phase

The development phase entails the projecting and construction of the three production platforms and related equipment. The development phase accounts for almost 70 percent of total costs of the Gullfaks project during the period analyzed.

The actual investment costs for the Gullfaks field were about NOK 11 billion below the initial budget (Statoil Annual Report 1988). This reflects a situation of fierce competition between Aker and Kværner who had both invested heavily in capacity both in terms of human and physical capital. Both needed large-scale projects and both had gone through shedding labor and restructuring after the first boom in the offshore sector in the mid 1970s. Norwegian Contractors actually lost NOK 325 million on its contract on outfitting the shafts of the Gullfaks C platform (Aker Annual Report).

3.2.1 Engineering

Since engineering is the most important service category in terms of total expenditure, we analyze this market in detail. Engineering services are divided into 7 subcategories:

1. Concept evaluation studies;
2. Project management services;
3. Pre – and detailed engineering/ design;
4. Project support functions and advisors;

¹⁰ This has, however changed with the establishment of Petroleum Geo Services (PGS) in 1991. The company has since been among the fastest-growing Norwegian companies, and is at present among the world leading oil service firms in the category maritime services.

5. Education and training;
6. Special studies, tests and processing.

Categories 2 and 4 clearly have to be provided on-site, while the other categories can more easily be traded and transferred over geographical distances. This is to some extent reflected in the Norwegian market share. However, albeit all the contracts in category 2 are awarded to companies located in Norway, foreign subcontractors are used such that the Norwegian market share is 89 percent. In category 4, a number of foreign companies are awarded contracts, providing the service through the movement of natural persons. The lowest Norwegian market share is found in the special studies category (76.6 percent) followed by pre-and detailed engineering (79.7 percent).

External purchases of engineering services accounted for only 2.2 percent of total development costs for the Gullfaks A platform, while this increased to 19.8 percent for the Gullfaks B platform and fell back to 15.2 percent of the Gullfaks C development expenditure. The small share for the A platform is partly due to the fact that the project largely copied Mobil's concept for the Statfjord platforms,¹¹ and partly because project management was undertaken in-house in Statoil's organization, assisted by Conoco. The C platform is a blueprint of the A platform, although the gravity base is larger. Engineering services were therefore probably of less relative importance to the C platform than to the B platform, also because the A and C platforms were built by the same firm. There has finally been an increase in productivity in engineering services over time such that engineering services per ton construction has declined.¹²

A market for **concept evaluation** appears to have been established with the Gullfaks C platform. We have found no contracts in the database for such services before 1985, indicating either that the database is incomplete or that the oil company performed concept evaluations in-house, in cooperation with the technical partners, Esso and/or Amoco. Once the market was established, however, it appears to have attracted a number of firms. Thus, 8 different firms shared the 12 contracts among them, with little competition on each contract, which could indicate that the market is specialized and characterized by niche firms.

Turning to the market for **project management services**, there are two large contracts registered in the PI base, one for the B platform and one for the C platform. Both are among the largest contracts awarded for the projects and thus included in table 1. The contracts had only one bidder, reflecting the fact that very few Norwegian firms had the capacity to manage such huge projects, while there was a policy objective to build such capacity in Norway. Project managing services represent a move to outsource coordination of the projects on the part of the oil company. The project management contracts are, however, different from the engineering, procurement and construction (EPC) contracts that became more common in later field developments. While the management contract is typically awarded to a third company different from the major contractor or operator, the EPC is a comprehensive contract with the major contractor.

¹¹ Interview with Jacob Bleie, Statoil.

¹² Information provided by Karl Johan Pedersen, Aker Maritime.

Pre- and detailed engineering and design is the largest subcategory under engineering in value terms. The Gullfaks project entailed 28 contracts in this subcategory, and 16 different firms were awarded contracts, with slightly less than 2 bidders per contract on average. There was, however, one dominant firm in the market, Aker Engineering, who gained a market share of 68.6 percent. The Norwegian market share was close to 80 percent for the subcategory as a whole, but there are large differences when we look at the functions the services have. Pre- and detailed engineering and design on the gravity base and shaft is totally dominated by Norwegian companies, gaining a market share of 100 percent. At the other end of the specter is engineering and design related to pipelines. Here the Norwegian market share is negligible.¹³ A low Norwegian market share is notable in all activities related to pipelines, which reflects weak capacity in this niche.¹⁴ The market for pre- and detailed engineering is thus characterized by one dominant firm and a relatively large number of specialized niche suppliers.

The project support functions and advisors' segment is less concentrated than the pre-engineering market. Thus, the firm gaining the largest market share accounted for about 24 percent of total expenditure. Statoil awarded 42 contracts to 29 different companies in this category. A large number of different firms receiving relatively small contracts suggest either that the market is highly specialized or that it is highly competitive.

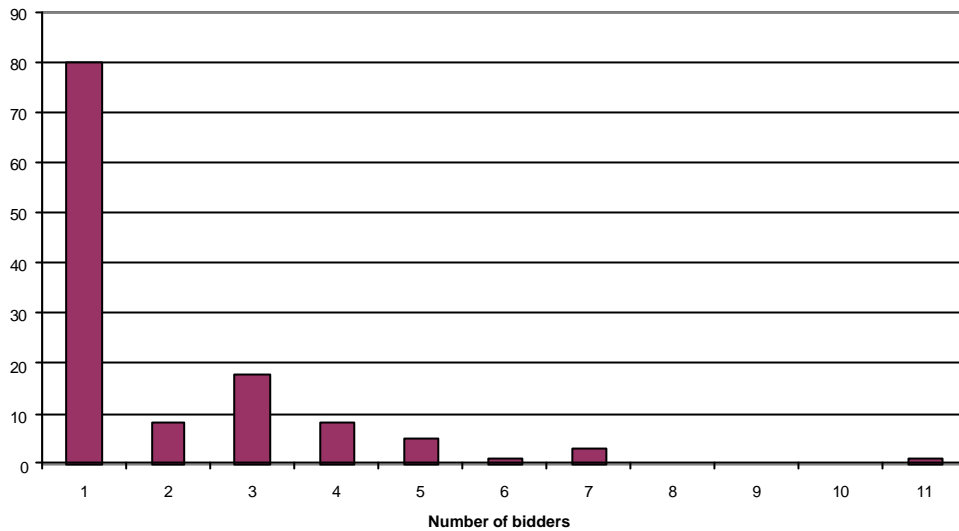
The market for **special studies, tests and processing** appears to be the most competitive and the most international among engineering services. There were on average 2.3 bidders per contract and the company with the highest market share gained about 20 percent of the market. The total number of contracts awarded was 31, distributed on 30 companies.

The nature of the market for engineering services is further illustrated by figure 3.

¹³ The only Norwegian input to this category recorded in the PI base is a small subcontract to a foreign contract.

¹⁴ This was also emphasized by Karl Johan Pedersen, Aker Engineering during an interview.

Figure 3: Number of bidders



The vertical axis measures the number of contracts; for example 80 (out of 124) contracts had only one bidder. A significant relationship between the value of the contract and the number of bidders can not be found (a negative correlation of -0.09). The Norwegian market share on engineering services is somewhat overestimated in the data. This is because both Norwegian-owned engineering firms and Norwegian subsidiaries of foreign engineering and oil service firms employed a substantial number of foreign engineers in their project organizations. Aker Engineering for example, employed about 50 percent of the engineers on a project basis, and a large share of these was foreign engineers, mainly from the US and UK (Aker Annual Report).

A general picture of the engineering market for supply to the Gullfaks field is a combination of a few large and relatively diversified Norwegian offshore companies who provide engineering services closely related to the construction work, which in turn is undertaken by the same offshore company. Thus, Aker and NPC, which merged in 1991, accounted for 78 percent of total engineering expenditure on the Gullfaks field. In addition there are a number of relatively small and specialized Norwegian engineering firms, competing alongside Norwegian affiliates of the multinational oil service and engineering firms and to a lesser extent with foreign firms without any establishment in Norway. In the PI base 58 different engineering firms (apart from Aker and NPC) are registered as suppliers to the The Gullfaks field, sharing among them 22 percent of the market.

3.2.2 Non-maritime services

The largest expenditure share on non-maritime services during the development phase are general services such as maintenance, sandblasting and other services. The more petroleum-sector specific services such as drilling, mud engineering, cementing of wells, testing and logging, and other well services are less prominent during the development phase. The market for the latter services is competitive with a relatively large number of bidders per contract and a relatively large number of firms in the market. The multinational oil service firms dominate, and the Norwegian market share is relatively small. Nevertheless, SINTEF, a research institution related to the

University in Trondheim was awarded a contract on geotechnical services in cooperation with a British service firm, and the Aker Group had established a well service firm, which was awarded one contract in competition with 2 international well service firms. Finally we observe that under the category other well services in the PI base, a number of contracts that entail both goods and services are included. This reflects the fact that equipment needs to be installed and serviced and in some cases the oil company purchases equipment that is operated by the seller.

In general it can be said that non-maritime services during the development phase largely bridge the exploration and production phases, particularly as far as drilling and well services are concerned. The sector is dominated by Norwegian firms in the sub-sectors that are least petroleum-sector specific, and by the multinational oil service firms in the more specialized (and high-technology) segments of the market. Finally, the market appears to be more characterized by long-term relationships than the engineering market (see section 4 below).

3.2.3 Maritime services

Maritime services appear to be the most competitive market during the development phase with an average of 3 bidders per contract and a Norwegian market share of only 61 percent. The composition of maritime services during the development phase is very different from the exploration phase as should be expected. While the exploration phase was dominated by services from seismic survey vessels, the development phase is dominated by services from cranebarges, flotels and pipelaying barges. More than 45 percent of the contracts (by value) went to services classified as installation of platforms and other structures. The 44 contracts registered in the PI base on maritime services during the development phase were spread on 29 different firms, none having a particularly large market share.

3.2.4 Summary, development phase

To summarize the findings on service inputs during the development phase, it is clear that although this is the least service-intensive phase, it still constitute the largest market in absolute terms. Further, the diversity of service inputs is also largest in this phase ranging from highly petroleum sector specific engineering services to general services such as rental of office space and catering. The market for the most project-specific services, engineering, is highly concentrated. Finally, we note that the quality of the service inputs during the early stages of a field development is crucial for the total cost of the project. Not only do the service sectors provide know-how and design crucial for effective planning and project management, they also lock in the technology and material choice for the life cycle of the project and thus largely determine the cost structure of the operation phase to which we now turn.

3.3 *The production phase*

The production phase starts when the field comes on stream and lasts until it is closed down. Statoil's onshore administration of the Gullfaks field is located in Bergen, and was initially a separate division within the Statoil organization. The main supply channel to the Gullfaks platforms goes through the Coast Center Base at Sotra outside Bergen, while catering and part of the supply services are administered from Fjord Base, located in Florø. The latter was established more for regional policy considerations than for reasons of cost-effective production of oil and gas. The Gullfaks C platform encountered some teething problems and production was below

plans during 1990 due to difficult reservoir conditions. Difficulties included problems with sand entering the wells and insufficient pressure. Both problems were addressed through technical adjustments (Statoil Annual Reports), and the field has later produced above the planned levels.

Our data base contains data up to 31.12.94, while the Gullfaks field is expected to produce for a long period of time after 1994. Thus, the analysis is based on a small fragment of total expenditure during the production phase. It has been a tendency during the 1990s to award service contracts covering several oil fields. The fields that are most often lumped together with Gullfaks are Veslefrikk and Statfjord, both operated by Statoil and located fairly close to Gullfaks. Further, the Gullfaks processing and storage facilities are also used for other nearby fields. It is therefore not always possible to extract from the PI base the operating cost of the Gullfaks field separately.

Service supply during the production phase is characterized by a flow of services over an extended period of time, unlike the development phase where services were more concentrated in time and often closely related to the construction or installation of equipment. Contractual relations during the development phase are therefore more long-term in nature. Our discussion on the operation phase below concentrates on engineering and non-maritime services since these are the largest sub-categories.

3.3.1 Engineering

The composition of engineering services is quite different from the exploration and development phases. Modification of existing structures and linking other smaller fields to Gullfaks are the most common activities. The contracts are generally small, and only 4 out of 39 exceed NOK 10 million. The number of firms involved in engineering contracts was 29, with no firm gaining more than 4 contracts. The dominant firm during the development phase, Aker, had a market share of 18 percent in this market.¹⁵

3.3.2 Non-maritime services

Figures 1 and 2 above show that non-maritime services are not only the largest cost category during the production phase, it is also the only service category for which the production phase constitutes the largest market. Among non-maritime services, drilling and well services are the most important. These services are much more complicated during the production phase than during the exploration phase. The wells are longer, more complicated and require a more complex completion process. The Gullfaks production phase up to 1994 includes 4 contracts on drilling, two relatively small on directional drilling awarded to the same company (Eastman Christensen), and two large, long-term contracts on production drilling awarded to Transocean.¹⁶ All four contracts had only one bidder.

There were 8 contracts awarded to mud-logging firms during the production phase of Gullfaks. Of these 5 contracts were for the Gullfaks field only, while 3 also covered Statfjord and Veslefrikk. The 5 contracts for Gullfaks only were relatively small and had one bidder only, while the contracts covering several fields were large and

¹⁵ The figure includes the supplies by Norwegian Petroleum Consultants before the merger with Aker.

¹⁶ Transocean was wholly owned by Aker under the name Aker Drilling until 1990, when Aker sold its majority stake but kept a minority stake in the company

attracted 4-5 bidders. Foreign firms and Norwegian subsidiaries of foreign firms dominate the market, but the Norwegian share is quite high compared to the average for non-maritime services; above 70 percent.

The Schlumberger group dominates the market for well cementing. There are 8 contracts of which the Norwegian subsidiary of Dowell Schlumberger was awarded 4, plus two additional contracts in cooperation with a Norwegian Service firm, Norwegian Well Service. The latter firm was awarded the remaining two contracts.

Comparing the relative importance of the three phases in terms of demand for non-maritime services, the production or operation phase constitutes more than three quarters of demand. Assuming that the operational phase will also increase in relative importance as Norway enters the stage of a mature oil producer, developments in this market as well as the other service markets is crucial for the future of the Norwegian oil-related producer service sector. This is also a phase where relational contracts are more important than during the development phase. The next section analyses contractual relations during the Gullfaks project and discusses the implications for the Norwegian offshore industry.

4 Contractual relations

The first Gullfaks contracts were signed during 1982. This was early in Norway's history as an oil producer. Statoil's procurement strategy was to put each part of the project up for tender and award contracts to individual companies on the basis of prices, quality and perceived ability to deliver. Development of an oil field at the time when Gullfaks was planned and developed went according to the following procedure:¹⁷

- The oil company decided on the extraction technology on the basis of studies made in-house and some purchased from outside;
- The oil company made estimates of costs and material needs, and planned the field development based on projecting, pre-studies and experience with similar fields;
- The oil company submitted the Plan for Development and Production to the Ministry of Oil and Energy¹⁸;
- The oil company invited major contractors to tender over a specified product or product package;
- The oil company entered into a number of contracts with suppliers of different elements of the production equipment and services. Materials such as steel and pipes were often ordered before the major contractors were chosen;
- The oil company was responsible for coordination of the development project, and also made most of the procurements;
- The major contractors were responsible for construction according to the oil company's detailed specifications. The oil company followed the construction process closely.

¹⁷ Information provided by Helge Hatlestad, Statoil during an interview. See also NOU 1999:11

¹⁸ The Plan for Development and Production is mandatory according the Norwegian petroleum legislation

These procedures put the oil company in the driver's seat as far as project design, technology choice and development and project management and control are concerned. Consequently, the majority of service contracts during the exploration and development phase is limited to one particular delivery of services, or a flow of services over a specified time period, indicating widespread arms-length trade between the supply industry and the oil company. However, since the Gullfaks field project has extended for about two decades, changes in contractual relations have occurred over time.

The first major change was Statoil's outsourcing of the management and project coordination of Gullfaks B and C construction. This turned out to be a costly organizational form and the mere size of Statoil's project management contracts with NPC suggests that coordination was a formidable task and that transaction and coordination costs were quite high. This led to experiments with new contractual forms during the Gullfaks C project when EPC contracts were introduced in order to economize on transaction and coordination costs. In the PI base, 10 EPC contracts, all classified under goods deliveries and all for the Gullfaks C platform, are registered. During the Gullfaks project it was a common practice that the operator, in this case Statoil, entered contracts with subcontractors who in turn delivered goods and services to the contractors. The largest contracts for materials delivery were entered between Statoil and the suppliers even before the major construction contracts were awarded. A practice of entering frame agreements with subcontractors on deliveries of material and other products has to some extent continued even for projects subject to EPC contracts.

During the Gullfaks field development the major contractors were organized as a number of loosely coordinated subsidiaries. Aker, for example, controlled 14 companies supplying goods and services for the oil sector in 1987. Within the group Aker Engineering did the design engineering, while Aker Stord did the fabrication engineering on Gullfaks A and C. The two had separate contracts with Statoil, who coordinated their work or outsourced coordination to NPC. Thus, if a problem arose in applying the design to fabrication, the cost of adjustments was born by Statoil. A substantial control system with inspections and more or less continuous on-site control was introduced in order to ensure quality.

A continuation of the trend towards a more widespread use of EPC contracts required integration and restructuring of the offshore industry in order to be efficient. The adjustment process has been a painful one as documented in a recent study of cost overruns on projects in the Norwegian petroleum sector (NOU:11), and at present (2000) the cost reduction objectives of new organizational and contractual forms have not been achieved.

Turning to a more detailed analysis of the contractual relations during the Gullfaks project, we note that out of a total of 448 contracts recorded under engineering, maritime services and non-maritime services, 96 were relational in one way or the other. We have classified as relational: long-term contracts with or without options, frame agreements and extensions of existing contracts. Relational contracts are most common during the operation phase where they account for 32 percent of total contracts awarded compared to 15 percent during the development phase and 6 percent during the exploration phase. Looking at service categories, relational

contracts are most common in the non-maritime services category where they accounted for 32 percent of the total number of contracts, compared to 13 percent in maritime services and 12 percent in the engineering category. It is worth noticing that relational contracts are most important in the sectors and phases where the Norwegian market share is the smallest. We found a correlation coefficient of -0.45 between the Norwegian market share and the percentage of contracts falling under our definition as relational. This may imply that as the Norwegian sector matures and the growth in the Norwegian market grinds to a halt, the Norwegian offshore industry has to build closer relations to the multinational oil companies and/or major international oil service firms in order to maintain and increase their activity level.

To conclude, vertical relations between the oil companies and the supply industry reflected the fact that the petroleum sector was an emerging, large-scale industry in Norway. Competence had to be built, the number of local players was limited and the state was heavily involved on the operator side. The sharp downturn in the world market price of oil in 1986 made cost reductions necessary and induced a process of experimenting with new incentive structures and new forms of vertical relations, such as the EPC contracts. Such changes have taken place within the Gullfaks project. However, the changes have only been partial, sometimes with elements of both worlds that appear to be inconsistent (e.g. frame agreements with subcontractors existing in parallel with EPC contracts).

5 Technological development during the project

The Gullfaks project in a way represents a gigantic learning by doing and technology transfer project. It was therefore important to apply known and proven technology. The Statfjord field, which was developed through a “build, operate, transfer” contract between Mobil and Statoil, had introduced the condeep platform to the Norwegian shelf of the North Sea. The Statfjord field was developed by three gravity base concrete platforms with an integrated steel deck. These platforms were built in Norway by Aker (the A platform) and Kværner (the B and C platforms). Mobil engaged multinational engineering and offshore companies in the projects with a large number of inspectors and supervisors on the construction sites. Nevertheless, the construction phase was rather chaotic with numerous changes in drawings and work that had to be scrapped and redone (Myklebust 1994). Shortage of skills and lack of experience led to delays and cost overruns, but it was also a learning experience and transfer of technology to the Norwegian oil and offshore sector which prepared the ground for the Gullfaks project.

Although Gullfaks applied known and proven technology, new innovations were made during the project. One of the most significant innovations during the development phase was related to reducing the total weight of the deck. It is of utmost importance for cost effectiveness to use light material in the extraction equipment. The deeper the sea, the more significant is the weight of the platform for cost-effectiveness. However, the use of light alloys was limited because they were difficult to weld. During the Gullfaks project, Aker and Statoil in cooperation with the University of Gent and Welding Cambridge developed lighter alloys that could be

welded easily and safely. These innovations have been important for later field developments and other industries as well.¹⁹

During the operation phase there has been continuous R&D in order to improve the extraction process, increase the recovery rate and reduce operating costs. Statoil has recently spent about NOK 0.5 billion a year on R&D, of which about 35 percent of expenditure is outsourced to external partners. These are Norwegian and foreign research institutions, and Norwegian and foreign supply firms (Statoil 1998). Among the most significant innovations related to the Gullfaks field are developments related to multiphase transport technology, which means that unprocessed mixtures of oil and gas can be transported over long distances through pipelines. This reduces costs substantially, since it reduces the density of offshore processing plants. Processing plants can in other words be concentrated on a few platforms or even onshore. The first field to utilize multiphase transport systems was the Gullfaks field. Unprocessed mixes are transported to the Gullfaks A platform from sub-sea wells and the B platform for further processing. A multiphase pump developed by Statoil in cooperation with the French oil company Total and the French Petroleum Institute has been installed on the Gullfaks platform in order to improve the effectiveness of multiphase transport. Although these new technologies were not developed particularly for the Gullfaks field, they were first adopted to this field together with the Statfjord field. Later the technology has become crucial for financial viability of smaller and more distant fields (Statoil Annual Reports).

The Gullfaks field has also been Statoil's most significant testing ground for full-scale testing of new technology. Among recent developments that have been developed or tested on the Gullfaks field, is a new system of computer based reservoir analysis and modeling that has increased recoverable resources by 30 million Sm³. Also new well planning systems, well repair technology, Surface Controlled Reservoir Analysis and Management System (SCRAMS) have been developed and tested out at the Gullfaks field (Statoil 1998). The Gullfaks field has finally been central in the process of providing data for improved capacity to analyze the properties of the reservoirs, and how to interpret the data.

The major contractor to the Gullfaks development, Aker, used agreements of cooperation and joint ventures with foreign firms in order to acquire technology. Joint ventures with the British engineering firm John Brown (Aker-John Brown), and Canadian SNC (SNC Aker Offshore) were set up, primarily in order to service the British and Canadian market respectively. However, the joint ventures were also a source of technology for servicing the Norwegian market in certain segments. In order to acquire and further develop floating and subsea solutions, Aker formed a joint venture with the American Vetco Gray (Aker Vetco). There is also a joint venture with a French company (Comex) with the objective of developing and supplying subsea solutions. In addition to joint ventures, Aker also made strategic foreign direct investments. Aker Engineering UK is established in order to service the British sector of the North Sea, but also to provide technical support to the services in the Norwegian part of the North Sea. These strategic alliances and investments are not related to the Gullfaks development as such, but they certainly

¹⁹ Information provided by Karl Johan Pedersen, Aker Engineering, during interview.

contributed to technology transfers that improved Aker's competitiveness both in terms of quality and cost effectiveness.

Identifying sources of technology to the Gullfaks project only takes us half the way towards understanding the role of the Gullfaks project in Norwegian offshore technology development. We also need to get a picture of the technology transfers from the Gullfaks project to other offshore projects and its contribution to general technological development in the economy at large. Since the Gullfaks project represented the fulfillment of one of the major objectives of Norwegian petroleum sector policies, namely to develop Norwegian petroleum and offshore sectors, we need to analyze the success of this "infant industry" policy. Did the Gullfaks development contribute to an internationally competitive petroleum and offshore sector, and have there been any technological spillovers to the rest of the economy? Or is the offshore industry a technological enclave that will disappear with the maturing and decline of the petroleum sector?

The material we have gone through, including interviews with key personnel both in Aker and Statoil has identified only one concrete case of technology spillovers to other sectors – namely materials technology related to the development of light alloys that can be welded. In contrast, we have not been able to identify new applications of the materials developed for the concrete substructures of the Gullfaks field. From the data base we have built on, supplemented with other sources of data, it appears that the industrial environment around Norwegian Contractors (NC) have all but disappeared. We have not found evidence that the materials technology developed for the concrete shafts and gravity bases has been the basis for a competitive advantage for Norwegian construction companies, for example. More research is necessary in this area before any firm conclusions can be drawn.

6 Summary and conclusions

The Gullfaks field development was in many ways the test case for the Norwegian petroleum sector, and the culmination of Norwegian infant industry policy towards the petroleum and offshore industry. It was the first field for which a Norwegian operator had the responsibility for all phases of the project; e.g., exploration, development and operation. Further, it was the first, and hitherto only significant field that had only Norwegian licensees. This does not mean that Norwegian companies possessed the skills and capacity to develop and operate the field on their own. Statoil had entered agreements of technical assistance with Esso and Conoco. Important sources of technology for the major contractors were joint ventures and mergers and acquisitions with foreign companies which were at the technology frontier. In addition, about half of the engineers engaged in the development of the Gullfaks field within the Aker Engineering organization were foreign engineers employed on a project basis. As should be expected in a country that had been an oil producer for only about a decade when the first contracts for the Gullfaks field were awarded, the project was a gigantic learning by doing project. Not only was the field development a technological challenge for a young petroleum and offshore industry, project management was also a formidable task where several approaches were tried out during the Gullfaks field development.

Although the Gullfaks field has adopted and applied well-proven existing technology, the field has become a central field for R&D during the operation phase. New technology has been developed for horizontal drilling, reservoir analysis, subsea systems and multiphase transport technology. Due to these R&D activities the infrastructure on the Gullfaks field can be fully utilized for a much longer period than originally planned and the cost per barrel of developing satellite fields are low because they can use existing infrastructure.

The Norwegian market share in service supply to the Gullfaks field is high, particularly for engineering services. The Norwegian service industry has, however, mainly focused on the development phase. This has hitherto been the largest and most protected market. It has been protected both in terms of preferential access for Norwegian companies and due to the fact that services during the development phase are closely related to the construction activity that had to be located close to the oil field. However, the relative importance of the development phase is likely to decline in the future both because the Norwegian sector is maturing and because large-scale platforms have lost ground to more cost-effective and flexible floating and subsea production systems. The Norwegian offshore sector therefore needs to either expand its activities to foreign field developments or restructure towards the operational phase, or both, in order to maintain and increase its activity level. The market for oil-related services during the operational phase is, however of a somewhat different nature than the development phase. First, it is characterized by more long-term and relational contracts than the development phase. Second, the oil companies typically demand a broad range of services as an integrated packet. Becoming part of the multinational oil companies' and/or the multinational oil service firms' supply chains is therefore probably crucial in order to grow in the market for oil related services.

One of the central questions raised in this study is to what extent producer services have contributed to technological development and technology transfers from abroad and technology diffusion from the petroleum/offshore sector to other sectors of the economy. We argue that producer services, particularly engineering, have been crucial to technology transfers from the multinational oil and offshore sector to the Norwegian industry. Transfers appear to have taken place more as a result of trade in services than as a result of costless technology diffusion. The mode of trade in services has been the movement of natural persons both as a part of an agreement of technical assistance and on a spot market basis. Agreements of technical assistance are mostly found on the part of the operator, while spot market purchase of engineering services through the movement of natural persons are most common on the part of the contractor. Foreign direct investments have also been an important mode of trade in services.²⁰ First, a number of foreign oil service companies have established subsidiaries in Norway. Second, Norwegian offshore companies have acquired foreign companies that command important offshore technology.

Technology diffusion from the Gullfaks field development to other sectors of the economy is more difficult to identify. We have identified materials technology development as one innovation that has been important to other sectors; namely the development of light alloys that can be welded. We have, however, not been able to identify diffusion of technology to other sectors in terms of diversification of the

²⁰ The WTO includes foreign direct investment as one of four modes of international trade in services, subject to the General Agreement on Trade in Services (GATS).

customer base of the offshore industry. Nor have we been able to identify an increase in exports of services such as large scale project management or exports of construction services based on the technology developed during construction of the concrete gravity bases and shafts. More research is, however, necessary in order to get a more comprehensive understanding of technology diffusion from the Gullfaks field development to the economy at large.

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Summary

This case study analyses the market for oil-related producer services for the Gullfaks oil field in the Norwegian part of the North Sea. We find that the market is highly concentrated, the Norwegian market share is extensive, and foreign companies service the Norwegian market mainly from their Norwegian subsidiaries. Relational contracts between the oil company and the service suppliers are most common during the operation/production phase and in the non-maritime services sector. We find a negative correlation between Norwegian market share and the extent of relational contracts in the market. Turning to sources of technology, we find that producer services have played a crucial role in the transfer of technology from multinational oil and offshore industries to the Norwegian petroleum sector. The channels of technology diffusion appear to have been agreements of technical assistance, mergers and acquisitions, joint ventures, foreign direct investments and employment of foreign professional staff on a contractual basis. It is, however, more difficult to identify technology diffusion from the Gullfaks field to the economy at large.