Received: 30 March 2020 | Accepted: 17 November 2021

DOI: 10.1111/sjpe.12304

ORIGINAL ARTICLE

Scottish Journal of Political Economy WILEY

Norwegian oil market concentration and its effects on the oil service companies 1993–2013

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Abstract

This paper explores the effect of market concentration of the Norwegian oil production sector (NPS) on Norway's second-largest industry, the oilfield services companies (OFS). To capture this effect, we use the system generalized method of moments approach (GMM) to estimate an empirical model, spanning the period 1993–2013. The findings indicate that increased market concentration is consistent with lower profitability of the oilfield services companies, as the bargaining power of oil companies relative to service companies increases. Increased knowledge about this effect could contribute to improving strategies for the further development of these industries by stakeholders.

KEYWORDS

bargaining power, market concentration, oil

JEL CLASSIFICATION

L13; L72; Q30; Q31

1 | INTRODUCTION

The Norwegian petroleum sector is the country's most important industry in terms of export revenue. National production is based on offshore oilfields, which are regulated by awarding licenses to oil companies, granting companies the right to extract oil and gas.[1] The oil production process, which is capital-intensive and requires a high degree of expertise, makes the petroleum sector a natural oligopsony with a large degree of market power

[1]A main operator is usually awarded leadership in the license, and other companies are incorporated as partner owners in the same license.

domestically.[2] Norwegian oil production companies (NPC in this paper) usually utilize services from oilfield service companies (OFS). The latter act as suppliers to NPCs, which, in a broad sense, constitute all the sectors that deliver goods and services to the NPCs.

Some academic publications and research have focused on the different issues related to Norway's OFS sector. For instance, see several publications by Eirik Vatne and some other studies.[3] These publications explore the policy aspects of the Norwegian oil sector, based on the application of descriptive statistics. Bjørnland (1998) conducted a more thorough analysis, in which she found that the oil and gas sector in Norway has benefited the output of the manufacturing sector.[4] However, this study does not differentiate the OFS sector from manufacturing in general. Bjørnland and Thorsrud (2016) also explored the link between the oil sector and other sectors in the economy by modelling productivity spillovers from the oil sector to other sectors of the economy. More recently, Bjørnland et al. (2019) analysed the potential spillover effects by including the OFS directly in a theoretical and empirical model. The literature on the economic impact of the NPC sector on Norway's second-largest industry, namely oilfield services companies (OFS), is still narrow, but gaining more attention.

In this paper, the effect of the market concentration of the NPC sector on the OFS sector is explored. To the best of our knowledge, no previous study has explored this mechanism in the Norwegian oil market. In theory, high market concentration with an oligopsony structure would imply high bargaining power (Chae & Heidhues, 2004; Porter, 2008; Simeone et al., 2017) for the NPC. The OFS sector delivers goods and services to the NPC sector, which grants the NPC sector potential oligopsony power. We follow a similar approach applied by Azar et al. (2017) and Benmelech et al. (2018) and use the Herfindahl-Hirschman Index as our measurement for market concentration. We explore this relationship using an empirical model by applying a generalized method of moments (GMM) estimator for the period 1993–2013. This paper focuses mainly on those OFS companies which most directly affected by the level of activities in NPC. More concretely, the OFS companies that produce oil platforms from which about a quarter of the total income of all OFS companies are derived.[5]

This paper contributes to two strands of literature. First is the literature concentrating on the Norwegian OFS sector, as this paper examines the effect of the concentration of Norwegian NPC sector. In this regard, the present study can be seen as complementary to Bjørnland et al. (2019). The second strand of literature is the industrial organization literature that has often focused on the effect of market power, see, for instance, Syverson (2019) for a literature overview.

More concretely, an empirical model is constructed with the revenue of the OFS companies as the main dependent variable. Market concentration is measured by the Herfindahl-Hirschman Index (HHI) and is the main independent variable. Following a brief overview of the OFS companies, the measurement of HHI in this paper is explained in Section 3. Section 4 describes the empirical model itself, with the controls, and Section 5 presents the results of the statistical analysis.

[2]Petroleum products are mostly exported, and Norwegian petroleum producers have little real market power internationally. These producers are therefore price takers internationally, but still have considerable market power over their domestic suppliers.

[3]See SNF (2000a, 2000b, 2002a, 2002b, 2004, 2006a, 2006b, 2013), Nordås et al. (2003), Prestmo et al. (2015) and Rystad Energy (2013). Other studies have explored the policy aspects of the Norwegian oil sector, for instance Thurber et al. (2011).

[4]Bjørnland (1998, pp. 562–563), using a structural VAR, found that manufacturing may have benefited in the short term from energy price shocks. She speculated that the mechanisms could be increased demand from the oil and gas sector or through increased subsidies from government revenues.

[5]Figures from Rystad Energy (2013 p. 13).

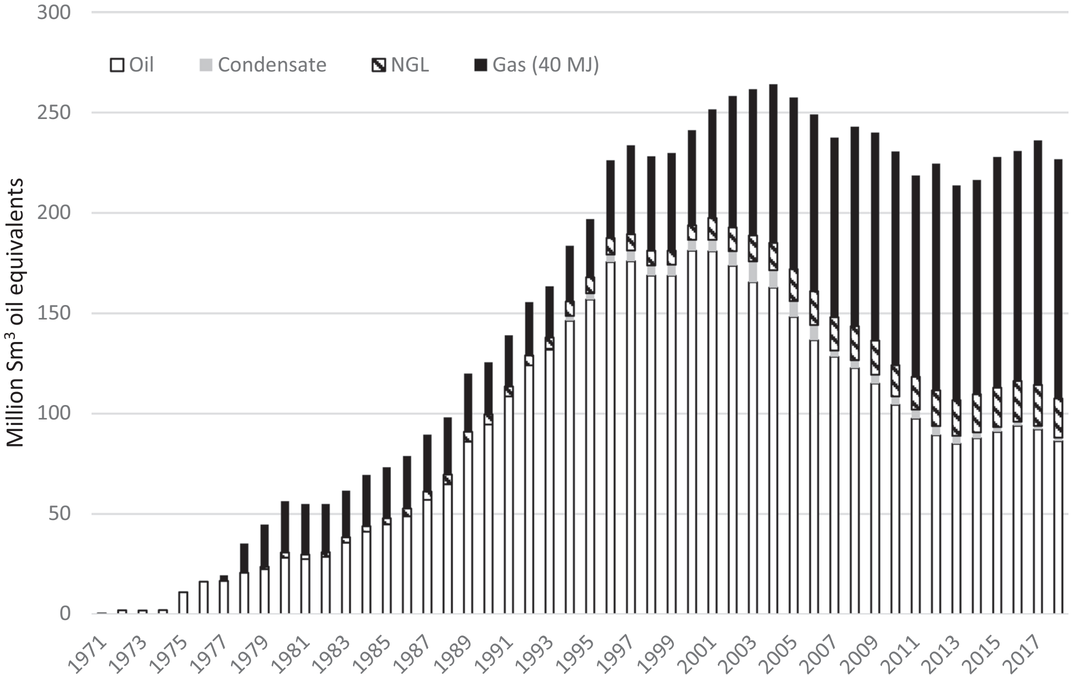

FIGURE 1 Annual production from the petroleum sector between 1971 and 2018, measured in millions of tons of oil equivalent Sm^3
Source: The Norwegian Petroleum Directorate (2019)

2 | OILFIELD SERVICES (OFS) COMPANIES

The Norwegian petroleum sector started in the early 1970s. From its inception, this sector steadily increased its production and exports, thereby elevating its importance to the Norwegian economy. As Figure 1 presents, production increased steadily until the early 2000s but has declined somewhat since then.

Increasing activity in oil and gas production in Norway aroused the interest of other companies that provided oil- and gas-related products or services to the upstream oil and gas industry. In this regard, the heterogeneous Norwegian oilfield service companies (OFS) developed in tandem with the increased activity in the oil sector itself, as the oil companies' demands for different products and services grew. The expansion of the industry was also characterized by increased demand for oil platforms to be built as well as drilling and engineering services. According to Heum (2008), four important factors determine the success of OFS companies. The first factor is related to the formal institutions that provide a stable business environment. The second factor is industrial policy measures, including protectionism, which has favoured Norwegian OFS companies over foreign competitors. The third factor is the prior existence of related competence. Finally, 'luck' has been an important factor: 1973 was a favourable time for the Norwegian petroleum sector because it marked an increase in the oil price. In addition, the shipping crisis of the 1970s might have worked in the oil supply industry's favour, as these facilities were at times converted from ordinary shipping to supply ships for the offshore sector.[6]

[6]Until the 1960s, shipping fabrication and construction was the most important industry in Norway, and it still occupies a unique position in the global maritime industry through its ship concentration, fabrication of ship equipment and maritime services. The Norwegian oil and gas industry has reaped the benefit of the knowledge and technology captured by the maritime industry in Norway since the 1960s. Despite the maritime-based knowledge advantages, Norway did not have the essential competencies and technology needed to run oil and gas production in the early 1970s. The Norwegian Government, therefore, introduced policies to attract global competence/ownership. Due to the presence of the large, partially state-owned operator Statoil, this sector developed in the interface between offshore hydrocarbons, maritime technology and insatiable European energy markets.

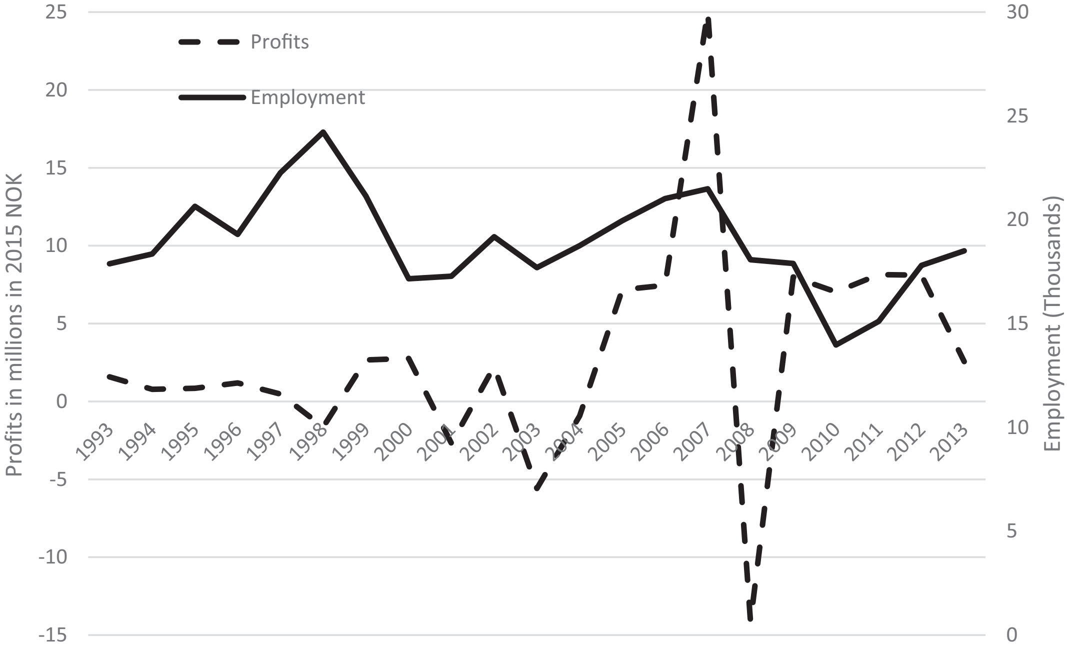

FIGURE 2 Annual profits (after-tax) and employment in the OFS sector 1993–2013
Source: Statistics Norway (2014)

The development of the OFS industry, while influenced by the petroleum industry itself, was different in terms of ownership structure. In the 1970s, the state exercised firm control over oil production through laws, state ownership of natural resources, the establishment of the Norwegian Petroleum Directorate (NPD) and through the state-owned company, Statoil.[7] However, government influence in the OFS industry was far less, as private ownership was not discouraged. However, there were still strong preferences for Norwegian ownership through different measures. Laws were implemented to allow for oil being transported to Norwegian soil, contracts had to follow Norwegian labour laws, and Norwegian had to be the primary language. Many of these protectionist tendencies were gradually reduced as increased competition was enforced through the European Union and WTO regulations.

While the definition of which companies are included as OFS companies varies by source, this paper follows the SSB definition using the Brønneysund register. As there are numerous segments of oil supply industries, our focus is on the production of oil platforms to limit the scope of the study. In 2012, the production of oil platforms constituted roughly 25 per cent of total oil services income.[8] Figure 2 shows the development of profits and employment from 1993 to 2013. Profits prior to 2004 were in general low, whilst the period after 2004 saw a marked

[7]Statoil was established in 1972. In the 1980s Norsk Hydro (with 51% government ownership) and Saga Petroleum (privately owned) entered the market. However, by 2009, all three companies had merged into one company, Statoil, which has evolved into a shareholding company in which the government has the majority share. In 2018, the board of Statoil proposed changing the company's name to Equinor. The name change supports the company's strategy and development as a wide energy company.

[8]Figures from Rystad Energy (2013, p. 13). The oil-producing segment of the market had an income of NOK90 billion. The second and third most important subsectors, oilfield development and subsea equipment, had an income of NOK50 and NOK40 billion, respectively. The reasons for focusing on oil platform producing companies are practical and theoretical. The practical reason is data availability and being able to differentiate between the delivery to oil and non-oil sectors. For instance, a hotel can also be classified as a NPC supplier if located close to the headquarters of an oil company, but given the type of general services provided it would be misleading to classify it as an oil supplier. Oil platforms are specifically designed to be delivered to oil companies and therefore are a better product to measure. The theoretical reason is that oil platform production involves one type of production (capital-intensive with high fixed costs) that could potentially be different from other oil supplying companies. Lumping all oil supplying companies together could therefore be misleading.

increase. The only exception is the financial crisis-related years 2008–2009. The total employment has been relatively stable with employment in 1993 close to the 2013 level.

3 | MARKET CONCENTRATION OF OIL AND GAS COMPANIES

The literature measuring market concentration has often used the Herfindahl-Hirschman Index (HHI).[9] A company's market share is defined as each company's share of total production:

$$s_j = \frac{\text{Production by company } j}{\text{Total production}} \tag{1}$$

Production is measured as net saleable oil equivalents (in million Sm^3), meaning that oil, gas, NGL and condensate are included in the production figures. Table 1 presents an overview of the five largest producers for various years. From 2001 onwards, the market structure has been relatively stable.

We follow the standard approach in the literature and use the Herfindahl-Hirschman Index (HHI). To construct the HHI using Equation (2), the share and production per field were used from the Norwegian Petroleum Directorate (2019). Joint ownership, mergers and name changes had to be considered to give the most accurate picture possible. The share of each company for each month was calculated using end-of-month figures. The index measures the sum of the individual shares squared:

$$\text{HHI} = \sum_{j=1}^{m} s_j^2 \tag{2}$$

The index value varies from a value $\frac{1}{m}$ (usually interpreted as low concentration) to 1 (one company produces everything). The usual interpretation is that an HHI ≥ 0.25 implies a high concentration and 0.15 ≤ HHI < 0.25 implies moderate concentration. Below 0.15 is considered unconcentrated.

The HHI is used widely in the literature but is not without criticism. Whinston (2006) claimed that cooperative behaviour between companies that would increase market power could take other forms than those measured with the HHI. Flath (1992) elaborated on one of these mechanisms, providing empirical evidence of anticompetitive behaviour as a result of horizontal shareholding. Matsumoto et al. (2012), using a Cournot oligopoly model, highlighted more theoretical concern regarding the ability of the HHI to capture market power.

For our purpose, while acknowledging the above weaknesses, the HHI is still very useful. First, the criticism's main claim is that market power could be larger than the HHI indicates. If correct, the HHI value provides a lower bound on market power, making our estimates of market concentration conservative. Second, it is an indicator of the trend of market concentration over time, which is important when doing regression analysis. Third, the HHI indicator was measured up against a more intuitive measure of market concentration, namely the combined market share of the three largest firms.[10]

As shown in Figure 3, the HHI has changed over time that can roughly be divided into different phases. In the first phase, between 1971 and 1976, Ekofisk was the only oilfield in production, explaining the stable value in those years. In 1977, three other oilfields started production. In the second phase, from 1977 to around 1986, there was a decline in market concentration. The number of oilfields increased, and there was a large number of production companies with small shares in total production. In the third phase from 1986 to around 2001, there was a trend towards increased market concentration. The number of oilfields increased, and the number of companies remained the same,

[9] For example, Hannan (1997), Manning (2003), Rubin and Joy (2005), Robinson (2011), Azar et al. (2017) and Benmelech et al. (2018).

[10] The Pearson correlation was 0.73 and statistically significantly different from zero at the 1 per cent level.

TABLE 1 Share of production for Norwegian oilfields for various years

Company	Share
1971	
Phillips Petroleum Company Norway	37.0%
Fina Production Licenses AS	30.0%
Norsk Agip AS	13.0%
Norsk Hydro Produksjon AS	6.7%
Elf Norge A/S	5.4%
1985	
Den norske stats oljeselskap a.s[a]	17.5%
Phillips Petroleum Company Norway	12.1%
Esso Exploration and Production Norway A/S	10.0%
Fina Production Licenses AS	9.3%
Elf Aquitaine Norge A/S	6.1%
2000	
Den norske stats oljeselskap a.s[a]	54.2%
Esso Exploration and Production Norway A/S	7.3%
Norsk Hydro Produksjon AS	6.7%
TotalFinaElf Exploration Norge AS	3.5%
Phillips Petroleum Company Norway	3.4%
2015	
Statoil Petroleum AS	32.2%
Petoro (SDFI)	27.5%
ExxonMobil Exploration and Production Norway AS	6.2%
Total E&P Norge AS	5.8%
A/S Norske Shell	3.9%

Note: Data from Norwegian Petroleum Directorate, 2019.
[a]Den norske stats oljeselskap a.s was in 2001 split into Statoil and Petoro (SDFI) respectively.

meaning that some companies increased production more than others did. In addition, from 1986, Statoil started to manage the State's Direct Financial Interest (SDFI) portfolio. In the fourth phase, beginning in 2001, there was a decrease in market concentration. Statoil chose in 2001 to partially privatise the company, as they could not continue to manage the State's Direct Financial Interest (SDFI) portfolio as they had managed from 1986.[11] The market concentration from 2001 until 2007 was relatively stable. The final phase, starting in 2007, increased the market concentration with the merger of Norsk Hydro and Statoil. By the end of 2009, when the process was completed, the new Statoil had a market share of roughly 35 per cent.

In comparison, the OFS industry has traditionally had lower concentration ratios than the NPC companies. Using company revenues to calculate market shares, an HHI index for the OFS companies can also be calculated as illustrated in Figure 4. This ratio is compared with a similar ratio for the NPC companies. It is clear that the market concentration ratio in the OFS industry has been lower than for the NPC companies.

[11]Petoro was then established to manage the SDFI portfolio. In our data, we use Petoro (SDFI) to be more accurate. 2001 saw the largest change in HHI in the entire period. Using data from Statistics Norway (2014), we can see that the average operating profits (in 2015 prices) of the OFS industry decreased from 1.607.927 NOK for the period 1993–2000 to an average of 1.186.255 NOK for the 2001–2013 period.

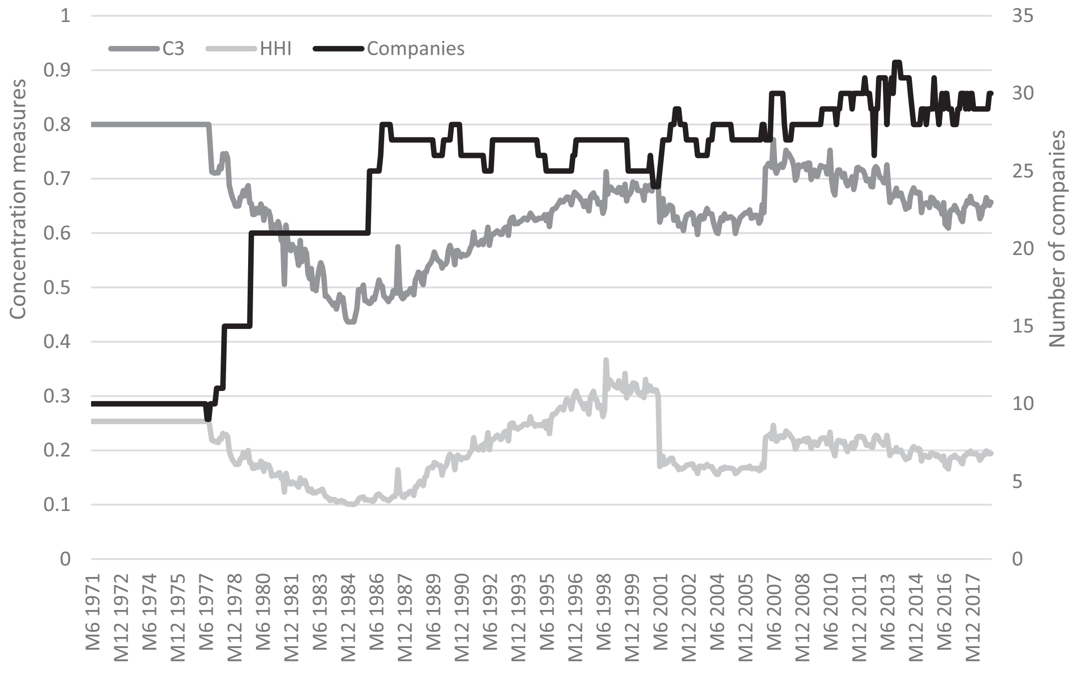

FIGURE 3 Number of oil companies, Herfindahl-Hirschman Index and the three firm concentration measure 1972–2018. Source: Own calculations based on Norwegian Petroleum Directorate (2019)
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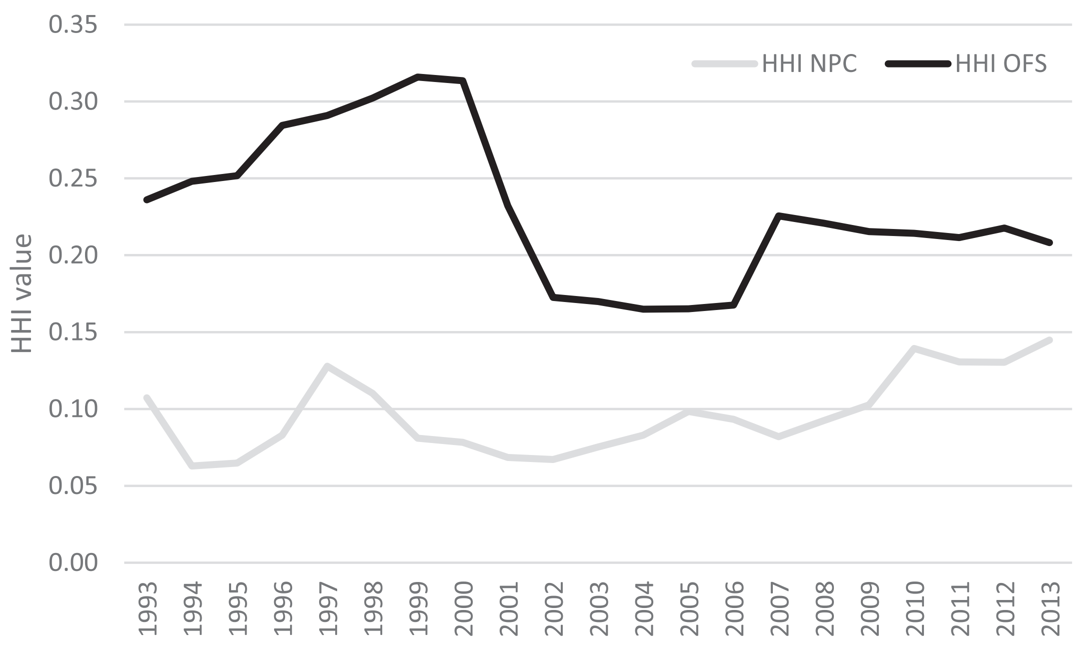

FIGURE 4 Herfindahl-Hirschassman Index based on yearly figures for both the NPC and the OFS sector 1993–2013
Source: Own calculations based on Norwegian Petroleum Directorate (2019) and Statistics Norway (2014)

4 | THEORETICAL MODEL

As the focus of this paper is on the effect of market concentration, our theoretical approach is to model it through a classical Cournot oligopoly model.[12] The market modelled is for goods supplied from the oilfield suppliers (OFS) to the Norwegian Petroleum Companies (NPC), for instance, oil platforms and equipment. OFS companies are generally capital-intensive, have a high degree of fixed costs and could, therefore, be a form of natural monopolies as average costs are decreasing.

4.1 | Determinants of bargaining power

The NPC companies, the consumers in this model, have a certain bargaining power which is modelled by a variable denoted γ:

$$\begin{gathered} \gamma = f(P^{\text{Oil}}, V^{\text{Oil}}, C^{\text{Oil}}) \\ \frac{\partial \gamma}{\partial P^{\text{Oil}}} < 0 \\ \frac{\partial \gamma}{\partial V^{\text{Oil}}} \lesseqgtr 0 \\ \frac{\partial \gamma}{\partial C^{\text{Oil}}} > 0 \end{gathered} \tag{3}$$

Equation (3) shows that the bargaining power of the oil companies is determined by the price of crude oil P^{Oil}, the uncertainty associated with the oil price, measured by its volatility V^{Oil} and the market concentration C^{Oil}.[13] It is assumed that an increase in the price of oil P^{Oil}, while increasing profits of NPC companies, decreases their market power as the demand for equipment for OFS goods increases. The effect of the volatility of oil price V^{Oil} on bargaining power is unknown. Market concentration C^{Oil} is assumed to increase the bargaining power of the oil companies, and thereby increase their market power. All these factors are treated as exogenous, as conversely, so is γ.

4.2 | Cournot oligopoly model

In the market, there are n OFS companies, where each company i's output is denoted by x_i, while the total output in the market is given by:

$$X = \sum_{i=1}^{n} x_i \tag{4}$$

To find the optimal solution for each company in the model, we must derive the reaction curve for each OFS company, which is obtained by maximizing the profits of each company. Let $X_{-i} = X - x_i$ denote total output in the market besides supplier i, c_i the constant marginal cost of supplier i, f_i the fixed costs of supplier i and $P(X, \gamma)$ the inverse demand function. Then the profit of the OFS company can be written as:

$$\pi_i(x_i, X_{-i}, \gamma) = x_i[P(x_i, X_{-i}, \gamma) - c_i] - f_i \tag{5}$$

[12]The literature on theoretical oligopoly markets is large; for surveys, see Okuguchi (1976) and Bischi et al. (2009).

[13]An alternative way to model that allows for bargaining power on the demand side would be an oligopoly-oligopsony model. However, this idea disregarded the nature of competition in the market. In reality, one specific oil platform is seldom contested by several oil companies at once, which means the oligopsony part would not describe this part of the market accurately.

To get the optimal solution for firm i, the profit is maximized with respect to the firm's output, x_i. This yields the first-order condition:

$$\frac{\partial \pi_i}{\partial x_i} = \frac{\partial P}{\partial x_i} \cdot x_i + P - c_i = 0 \tag{6}$$

Solving the first-order condition with respect to the quantity x_i yields the reaction curve:

$$x_i = r_i(X_{-i}, \gamma) \tag{7}$$

For simplicity, the model is solved using a linear parameterization in which,

$$P = A(\gamma) - BX = A(\gamma) - B(x_i + X_{-i}) \tag{8}$$

The intercept term $A(\gamma)$ is dependent on the bargaining power γ of NPC companies, and any change in the bargaining power of the NPC Company can, therefore, change the intercept of the demand function.[14] Using this parameterization, one can solve the profit maximization problem to obtain the following reaction curve for firm i:

$$x_i = r_i(X_{-i}, \gamma) = \frac{A(\gamma) - c_i}{2B} - \frac{1}{2}X_{-i} \tag{9}$$

Equation (9) leads to n reaction curves, meaning n simultaneous equations to solve. For simplicity, we assume that the marginal costs are the same for all OFS companies $c_1 = c_2 \cdots = c_n = c$. Summarizing the n different reaction curves yields:

$$-BX(n+1) + nA(\gamma) - nc = 0$$

We can use this condition to derive the total market output (10) and market-clearing price (11):

$$X = \frac{n}{n+1} \cdot \frac{A(\gamma) - c}{B} \tag{10}$$

$$P = \frac{1}{n+1}A(\gamma) + \frac{n}{n+1}c \tag{11}$$

As we assumed that $\frac{\partial P}{\partial \gamma} < 0$, it means that any increase in bargaining power will decrease the total output in the market and the equilibrium price. The intuition for why the equilibrium price decreases with bargaining power is because γ is the bargaining power of the consumers (NPC companies), not the producers (OFS companies). As in oligopsony models, an increase in the bargaining power for the consumer would lead to a lower market-clearing price. For an OFS company i, the quantity produced and profit will be.

$$x_i = \frac{n}{n+1} \cdot \frac{A(\gamma) - c}{B} \tag{12}$$

$$\pi_i = \frac{1}{(n+1)^2} \frac{(A(\gamma) - c)^2}{B} - f_i \tag{13}$$

The outcome of the model is that the profit of the supplier company will be affected by:

[14] An alternative parametrization could be to allow the bargaining power γ to affect the slope as well, in effect $B(\gamma)$. This alternative is explored further in Appendix B.

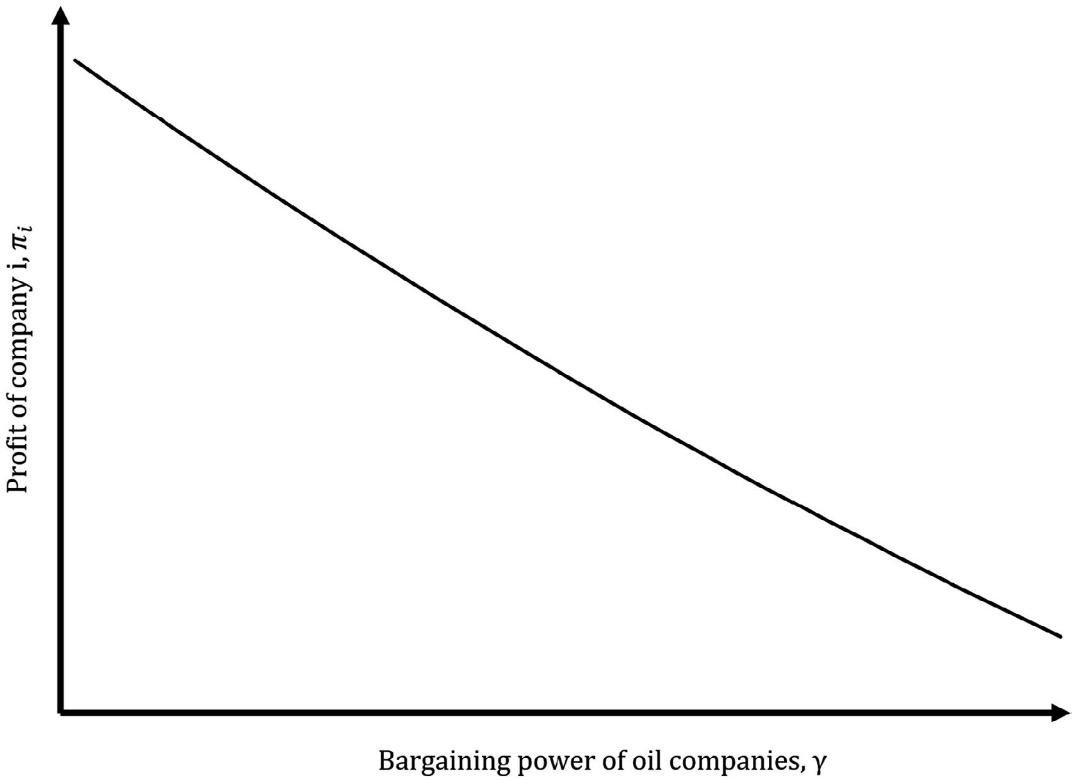

FIGURE 5 Profit as a function of bargaining power

- The number of OFS suppliers, n: The higher the number of oil company suppliers, the lower the profit.
- Bargaining power of oil companies γ. It is assumed that
  a. An increase in oil prices P^{Oil} increases profits as the oil companies' demand for OFS goods increases.
  b. An increase in the market concentration O^{Oil} decreases profits as the bargaining power of oil companies relative to OFS companies increases.
- Marginal costs, c, and fixed costs, f_i: An increase in costs decreases profit.
- The slope of the demand function, B: Represents the price elasticity, which is assumed to below as there are no real substitutes for the goods provided by the OFS sector.

Most relevant for this paper is the effect of the bargaining power of oil companies γ, which shows the degree of monopsony power, as illustrated in Figure 5. The relationship shows that an increase in the bargaining power of the NPC companies, γ, decreases the profit of OFS companies. A numerical example of this model is shown in Appendix B.

5 | METHODOLOGY, DATA AND ESTIMATION TECHNIQUE

5.1 | Empirical model and estimation technique

The empirical model is shown in Equation (14) below and is based on the theoretical model presented in the previous section. The dependent variable is the profits of the OFS companies measured in real 2015 NOK.

$$\pi_{it} = \alpha\pi_{it-1} + \beta_0 + \beta_1 C_{t-1}^{\mathrm{Oil}} + \delta \mathbf{X}_{t-1} + \mu_i + \partial_t + \varepsilon_{it} \tag{14}$$

The dependent variable π_{it} is the real profits of an OFS company *i* during period *t*, while π_{it-1} is the same variable lagged.[15] The main explanatory variable, C_{t-1}^{Oil}, shows the market concentration of NPC during period *t*–1 measured by the HHI. It is lagged by one period, as the effects of market concentration are expected to have a lagged effect given the nature of the industry. Oil platforms and other equipment typically take years to produce, and the contracts for these transactions are made prior to construction. Naturally, profits during period *t* are determined by contracts that were agreed upon during period *t*–1 or prior. $\boldsymbol{X}_{t-1}$ is a vector of control variables that are also lagged for the same reason as stated above. μ_i is the unobserved firm-specific heterogeneity, ∂_t is time-specific factor and ε_{it} is the error term.

The model is estimated using the system generalized method of moments (GMM), as proposed by Arellano and Bover (1995) and Blundell and Bond (1998). This estimation technique allows the estimation of a dynamic model and addresses problems of endogeneity, measurement errors and omitted variables. The period analysed is from 1993 to 2013, which is divided into seven non-overlapping periods of three years each, meaning the values taken are three-year averages. This choice was made as the focus was on the long-term trend, rather than short-term fluctuations. The norm is to have five-year averages, but in this case, this would be inefficient because it would mean the last year was dropped and would lead to many observations being dropped, as the panel is unbalanced.

The estimation uses a two-step approach, which is now standard to estimate the weighting matrix. As proposed by Roodman (2009), the standard errors were corrected for small sample bias based on the Windmeijer (2005) method. Three specification tests are run. First is the Hansen (1982) test of overriding restrictions to test for the validity of the moment conditions. Second is the Arellano and Bond (1991) test for the presence of second-order serial correlation in the error term. Finally, the Windmeijer (2018) underidentification tests both the strength and the relevance of instruments.

The main independent variable, the HHI, has two large shocks. The first is in 2001, with a large drop in the HHI caused by the splitting into Statoil and Petoro, which is caused by the partial privatization of the former. It is therefore uncertain whether the effect on bargaining power is as large as the change in HHI would indicate. The second is the increase in HHI in 2007 caused by the merger of Statoil and Hydro. To ensure that these shocks are controlled for, period dummies are added in the system GMM approach. In addition, the three-firm concentration ratio (C3) presented in Section 3 is added as an alternative measure of market concentration. C3 did not experience a similar large drop in 2001 as the HHI. The results using the three-firm concentration ratio and the HHI should be roughly similar, if there is an effect of market concentration. A final robustness check is conducted by estimating the empirical model with alternative estimation techniques.

5.2 | Data

Data on the main dependent variable were derived from yearly profits measured in million NOK from the oilfield supply (OFS) companies and were provided by Statistics Norway (2014). The confidential nature of the data did not allow for the identification of the nature of firms leaving the dataset, which could be the result of acquisition, bankruptcy or mergers, among others. As the focus was on companies that produced capital-intensive equipment, which excludes a small workforce, our preferred measure was the profit of firms with an average employment of at least 25 and had at least 50 employees most years. This threshold leaves us with mainly the oil platform producing companies that are the focus of this study. This cut-off point is arbitrary;

[15]The dependent variable is not measured in logarithms as profits can be negative, and the practice of using logarithms plus a scalar is increasingly being criticized. Other ways of measuring the dependent variable were tried, including the revenue/cost and the profits plus the balance sheet, but there were issues with non-specification using both these measures. All results are available upon request. As profits are the most straightforward measure, we chose to keep this measure as the main dependent variable. As a robustness check the hyperbolic sine transformation of profits was done instead, and the results are shown in Appendix C, these are largely the same as the main results.

therefore, a robustness check is performed to analyse how a different cut-off point affects the results. To improve the quality of the data, all countries that were holding companies that had no income were dropped. Finally, income was deflated using a price deflator for manufacturing and mining from Statistics Norway (2019).[16]

The variable C_t^{Oil} shows the market concentration of NPC during the period t. It is measured by the HHI, as shown in Figure 3. Its construction and sources have already been explained in Section 3. In our analysis, we used figures derived from the NPC yearly average of HHI. Our hypothesis in the theoretical model (in Section 4) is that the sign of β_1 is negative, as an increase in market concentration increases the bargaining power of the oil companies, and thereby decreases the income of the OFS companies. To test the robustness of the HHI measure, we also run the same regression with an alternative measure of market share, namely the share of the three, four and five largest companies respectively.

There are five control variables to check the robustness of the results. First is the real Brent crude oil price for the specific period taken from BP (2018); an increase is expected to increase demand and increase income. Second is the coefficient of variation in the real oil price using monthly data from the EIA (2019) to give an indication of the volatility of the oil price, which could affect income, as the model in Section 4 predicted, but with an unknown sign. The third is the real long interest rate, which is the annual average returns on 10-year government bonds adjusted for inflation to capture opportunity costs; the data are from (Norges Bank 2019).[17] Fourth is the number of OFS companies. Finally, there is the logarithm of the stock of total real capital from the same dataset as revenue and deflated with the same deflator to obtain real values. For more details on the data and their sources, see Appendix A.

6 | EMPIRICAL FINDINGS AND DISCUSSION

The main results of the empirical model are presented in Table 2.[18] Column (2–1) shows the results for our preferred indicator, the HHI. Market concentration has the expected sign and is statistically significant at the one per cent level. The results are consistent with the theoretical model in that a higher market concentration is correlated with lower revenues of the OFS companies during the subsequent period. This effect is estimated to be roughly 6599 million NOK (for a one percentage point increase in the HHI value).[19] The standard error of 2069 million NOK implies a 95 per cent confidence interval with a lower bound of −10,703 million NOK and an upper bound of −2494 million NOK.

As a robustness check, the same specification was run using the market share of the three, four and five largest firms respectively as an alternative to the HHI in columns (2–2)-(2–4) in Table 2. The coefficient obviously changes as the measurement is different. However, most importantly, the effect of market concentration still has the same sign and is still significant at the five per cent level for the three and four largest firms. The measure decreases in significance the higher share of companies, which is natural as there less variation in the market share of five firms relative to three firms.

The decision to only include the firms that had an average employment of 25 might have affected the results of the analysis. To check for this, the results were re-run for several cut-off points (see Table 3). The first column in Table 3 includes all available observations. The group with less than 25 employees did show a significant effect

[16]A producer price index for the “oil and gas extraction, manufacturing, mining and quarrying and electricity, gas and steam supply” was used with 2015 as the base year.

[17]To test the robustness of the maturity of the bond, the regression also used 3-year and 5-year government bonds.

[18]Two control variables, the long interest rate and the stock of real capital, were dropped from the final model based on the results of the underidentification tests.

[19]All monetary values are in 2015 fixed Norwegian kroner (NOK).

TABLE 2 Effect of market concentration on profits for various concentration measures. Dependent variable is the profit of OFS companies in period t

	(2–1)	(2–2)	(2–3)	(2–4)
π_{t-1}: Profit OFS companies t–1	0.464***	0.402*	0.410*	0.398
	(0.174)	(0.211)	(0.229)	(0.290)
HHI_{t-1}: HHI for NPC t–1	−6599***			
	(2069)			
$C3_{t-1}$: NPC market share 3 largest companies t–1		−12745***		
		(4600)		
$C4_{t-1}$: NPC market share 4 largest companies t–1			−17822**	
			(7544)	
$C5_{t-1}$: NPC market share 5 largest companies t–1				−25106*
				(14476)
P^{Oil}_{t-1} : Logarithm of real oil price t–1	215526***	243725***	243773***	247346***
	(32973)	(33130)	(35121)	(36066)
V^{Oil}_{t-1}: CV real oil price t–1	13608***	14044***	13933***	8808***
	(3101)	(3221)	(3351)	(2128)
n_{t-1} : Number of OFS companies t–1	−2239	−3689*	−3202	−2046
	(1435)	(1997)	(2191)	(2295)
Observations	275	275	275	275
Groups	103	103	103	103
Instruments	13	13	13	13
Time dummies	Yes	Yes	Yes	Yes
GMM instrument lag	1	1	1	1
AR(2) test p-value	0.360	0.364	0.366	0.371
Hansen OID test p-value	0.206	0.122	0.104	0.081
Underidentification test (Cragg-Donald)				
p-value	0.0090	0.0105	0.0080	0.0133
Test statistic	18.76	18.36	19.06	17.72
Degrees of freedom	7	7	7	7
Underidentification test for regressors (Sanderson-Windmeijer conditional underidentification tests p-values)				
HHI_{t-1}: HHI for NPC t–1	0.0000			
$C3_{t-1}$: NPC market share 3 largest companies t–1		0.0000		
$C4_{t-1}$: NPC market share 4 largest companies t–1			0.0000	
$C5_{t-1}$: NPC market share 5 largest companies t–1				0.0000

Note: Values in parenthesis are Windmeijer robust standard errors. ***, ** and * indicate significance levels of 10%, 5% and 1% respectively. Intercept and time dummies not reported for brevity. For the Sanderson-Windmeijer tests for underidentification only the p-values for the market concentration are reported for brevity.

of market concertation, but the p-value of the underidentification test indicates that the model might be misspecified. Focusing on the largest companies with the employment of over 25, 50, 75 and 100 respectively (column [3–3], [3–4], [3–5] and [3–6]), the size of the coefficient increases as the cut-off point is changed. However, the standard errors also increase, meaning that we are less certain of the size effect. Importantly, however, is that all the 95 per cent confidence interval all overlap regardless of subsample.

TABLE 3 Effect of market concentration on profits for different subsamples based on employment. Dependent variable is the profit of OFS companies in period t

	All	<25	≥25	≥50	≥75	≥100
	(3–1)	(3–2)	(3–3)	(3–4)	(3–5)	(3–6)
π_{t-1}: Profit OFS companies t–1	0.456***	0.111	0.464***	0.331	0.326	0.271
	(0.159)	(0.264)	(0.174)	(0.208)	(0.213)	(0.209)
HHI_{t-1}: HHI for NPC t–1	−6244***	−9917***	−6599***	−8067***	−9021***	−9754***
	(1826)	(3389)	(2069)	(2448)	(2758)	(3143)
P^{Oil}_{t-1}: Log of real oil price t–1	221203***	176168***	215526***	188815***	179280***	165003***
	(29286)	(28338)	(32974)	(36198)	(43251)	(52331)
V^{Oil}_{t-1}: CV real oil price t–1	13773***	19428***	13608***	13954***	15010***	15379***
	(2713)	(4604)	(3101)	(3581)	(4024)	(4298)
n_{t-1}: Number of OFS companies t–1	−2378*	−5799***	−2239	−2945*	−3070*	−3770**
	(1287)	(1844)	(1435)	(1656)	(1772)	(1837)
Observations	351	76	275	209	183	162
Groups	143	40	103	75	63	56
Instruments	13	12	13	13	13	13
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
GMM instrument lag	1	1	1	1	1	1
AR(2) test p-value	0.370	0.237	0.360	0.357	0.365	0.346
Hansen OID test p-value	0.297	0.210	0.206	0.295	0.107	0.482
Underidentification test (Cragg-Donald)						
p-value	0.0004	0.1588	0.0090	0.0265	0.0010	0.0000
Test statistic	26.45	9.27	18.76	15.85	24.23	33.00
Degrees of freedom	7	6	7	7	7	7
Underidentification test for regressors (Sanderson-Windmeijer conditional underidentification tests p-values)						
HHI_{t-1}: HHI for NPC t–1	0.0000	0.0098	0.0000	0.0000	0.0000	0.0000

Note: Values in parenthesis are Windmeijer robust standard errors. ***, ** and * indicate significance levels of 10%, 5% and 1% respectively. Intercept and time dummies not reported for brevity. For the Sanderson-Windmeijer tests for underidentification only the p-values for the market concentration are reported for brevity.

TABLE 4 Effect of market concentration on profits using alternative estimation techniques. Dependent variable is the profit of OFS companies in period *t*

	Difference GMM (4–1)	Fixed effects (4–2)	Fixed effects (4–3)	Pooled OLS (4–4)	Pooled OLS (4–5)
π_{t-1}: Profit OFS companies *t*−1	0.142		−0.300		0.429
	(0.592)		(0.184)		(0.277)
HHI_{t-1}: HHI for NPC *t*−1	-13349^{***}	-8333^{***}	-9842^{***}	-8130^{***}	-6982^{***}
	(3495)	(2594)	(3079)	(2115)	(2498)
P^{Oil}_{t-1}: Log of real oil price *t*−1	71157	128577^{*}	140442^{***}	140969^{**}	150901^{***}
	(69607)	(65743)	(52797)	(57649)	(52218)
V^{Oil}_{t-1}: CV real oil price *t*−1	16801^{***}	10760^{***}	10504^{***}	9280^{***}	−64
	(4455)	(2863)	(2467)	(2338)	(3633)
n_{t-1}: Number of OFS companies *t*−1	−4127	-5418^{***}	-7001^{***}	-5849^{***}	-5622^{*}
	(4467)	(784)	(1302)	(773)	(2873)
Observations	275	275	275	275	275
Groups	103	103	103		
Instruments	13				
Time dummies	Yes	Yes	Yes	Yes	Yes
Company fixed effects		Yes	Yes	No	No
R-squared		0.6886	0.7182	0.6729	0.7230
GMM instrument lag	1				
AR(2) test *p*-value	0.337				
Hansen OID test *p*-value	0.630				
Underidentification test (Cragg-Donald)					
p-value	0.0002				
Test statistic	28.17				
Degrees of freedom	7				
Underidentification test for regressors (Sanderson-Windmeijer conditional underidentification tests *p*-values)					
HHI_{t-1}: HHI for NPC *t*−1	0.0001				

Note: Values in parenthesis are Windmeijer robust standard errors for the difference GMM. For fixed effects and pooled OLS, values in parenthesis are *t*-values based on clustered standard errors. ***, ** and * indicate significance levels of 10%, 5% and 1% respectively. Intercept and time dummies not reported for brevity.

The choice of estimation technique, the system GMM, was based on the need to control for omitted variables and endogeneity. To test whether the results changed if we changed the estimation technique, we estimated the model using difference GMM, fixed effects (FE) and pooled ordinary least squares (OLS). The results are presented in Table 4, and in all specifications, the HHI is statistically significant at the one per cent level. For the difference GMM in specification (4–1), the point estimate is largest of any specification. The standard error is higher than for the similar estimate for the system GMM, and both the 95 per cent confidence intervals overlap. For the fixed effects and pooled OLS, the estimates of the effect of HHI are consistent with the results of the system GMM reported in Table 2.[20]

[20]A final robustness check was to transform profits using the hyperbolic sine transformation. The results, reported in Appendix C, remains consistent with the previous results.

These results are consistent with the literature on the effect of market concentration effect on monopsony power in general, see for instance Manning (2003), Azar et al. (2017) and Benmelech et al. (2018). All these previous researches, however, studied the labour market rather than the oil market. Our findings are also consistent with studies that have found an impact of oil companies on OFS production and productivity, such as Bjørnland et al. (2019). Taken together, though, both these strands of literature support our conclusion.

The main causes for the changes in market concentration lie in economic policies. Ownership of licences are highly politicised, and the government has, on several occasions, affected this process directly. Two major events in the period of analysis (Section 3) highlight this influence. The first event was the splitting of Statoil and Petoro (SDFI) in 2001, causing a drop in market concentration. The second example was the merger between Statoil and Norsk Hydro in 2007 to create a stronger internationally competitive oil company.

The policy implication of our analysis is that such decisions have consequences for the OFS sector. Increased market concentration, such as the merger of 2007, might have had a negative effect on the income of the OFS sector. These results indicate a policy trade-off might exist between (i) maximizing the oil company's economic potential abroad and (ii) the adverse effect on the income of OFS companies.

7 | CONCLUSION

This paper has explored the link between the market concentration of Norwegian Petroleum Companies (NPC) and oilfield suppliers (OFS) through analysing the effect of NPC's market concentration on the OFS's income. Using system GMM, the results indicate that an increase in market concentration of NPC was correlated with a decrease in OFS's income.

While these results are consistent with theory and previous studies on the relationship of market concentration in other markets, follow-up studies are required. A richer dataset that can distinguish the types of entries and exits, among other things, would lead to a better understanding of the relationship between market concentration in the petroleum market and the supply industry. In addition, as both NPC and the OFS rely heavily on international markets, including this dimension could be the topic of another study.

The political interest in the oil production industry, partly created by increasing focus on climate change, makes this sector volatile and uncertain. Political decisions, made by the Norwegian government, might affect the market concentration of NPCs, for instance by awarding licenses to the oil companies granting them the right to extract oil and gas. As market concentration increases, volatility will continue to shape OFS's strategy. To meet challenges, in the long term, the oil service companies need to make their services profitable against growing uncertainties in the market.

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How to cite this article: Bruno, L.C. & Steen, R. (2021) Norwegian oil market concentration and its effects on the oil service companies 1993–2013. *Scottish Journal of Political Economy*, 00, 1–21. Available from: https://doi.org/10.1111/sjpe.12304

APPENDIX A

Variable	Description	Sources
Profit for an OFS company	Reported end of year operating profit of each individual OFS company in million NOK	Confidential dataset provided by Statistics Norway (2014)
HHI for NPC	The Herfindahl-Hirschman Index is based on yearly averages for each NPC's monthly market share figures based on the formula: $\text{HHI} = \sum_{j=1}^{m} s_j^2$	Own calculations based on Norwegian Petroleum Directorate (2019)
Real oil price	Yearly real Brent crude oil price as presented in the British Petroleum Statistical Review of World Energy	British Petroleum (2018)
CV real oil price	Coefficient of variation of monthly real oil prices. As the real prices from oil from BP (2018) were yearly, these had to be taken from another source. The coefficient of variation is the standard deviation divided by the mean: $\text{CV} = \frac{\text{Standard deviation}}{\text{Mean}} = \frac{\sigma}{\mu}$	Own calculations based on the US Energy, Information Administration (2019)
Real interest rate	Calculated as the annual average returns on 10-year government bonds and adjusted for yearly inflation using the consumer price index. The real interest rate formula was used: $\text{Real interest rate} = \frac{1+\text{Nominal interest rate}}{1+\text{Inflation}} - 1$	Nominal interest rate figures were from Norges Bank (2019), whilst the consumer price index figures were from Statistics Norway (2019)
Number of OFS companies	Number of OFS companies in the data. As three-year averages are calculated, this figure represents the average number of companies within this period	Confidential dataset provided by Statistics Norway (2014)
Stock total real capital	Defined as total assets for each company's balance, meaning the sum of short-term liabilities, long-term liabilities and equity. Initially equity was preferred, but was dropped as some equity observations were negative.	Confidential dataset provided by Statistics Norway (2014)

APPENDIX B

Numerical example 1: Change in intercept only

To calculate profits for the OFS companies, we use Equation B1 (same Equation [13]):

$$\pi_i = \frac{1}{(n+1)^2}\frac{(A(\gamma)-c)^2}{B} - f_i \tag{B1}$$

The intercept is a decreasing function of bargaining power as shown in Equation B2. The intuition is that an increase in bargaining power by the consumers (here the NPC companies), means that producers (here the OFS companies) obtain a lower market-clearing price. In effect, the more bargaining power the consumers have, the further inward the demand curve lays.

$$A(\gamma) = a_1 - a_2\gamma \tag{B2}$$

For a numerical example, we let

$n = 5$
$c = 100$
$f_i = 25{,}000$
$B = 2$
$a_1 = 1000$
$a_2 = 1000$

To calculate profits, we allow γ to increase from 0 to 0.30 in increments of 0.01. The results are shown in Figure B1.

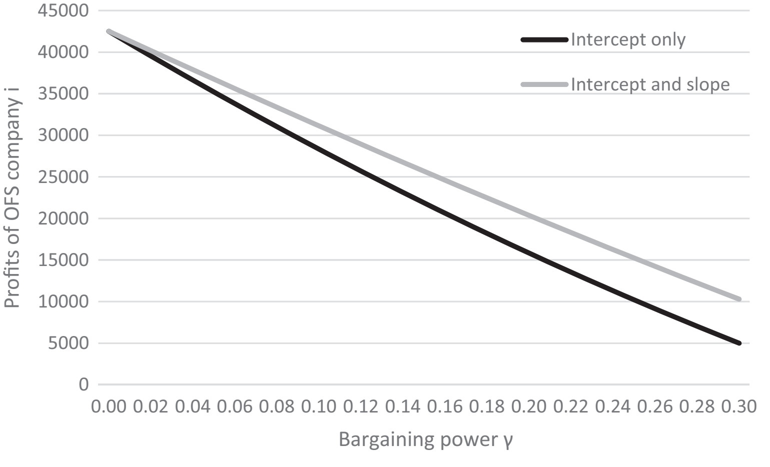

FIGURE B1 Profit of OFS company *i* as a function of bargaining power

Numerical example 2: Change in intercept and slope

To allow for an additional effect on the slope of the demand curve, we now allow the slope to vary as a function of bargaining power, $B(\gamma)$. Equation B1 can be re-written as Equation B3:

$$\pi_i = \frac{1}{(n+1)^2}\frac{(A(\gamma)-c)^2}{B(\gamma)} - f_i \tag{B3}$$

The (negative) slope can further be modelled as a decreasing function of bargaining power as shown in Equation B4. The intuition is that an increased bargaining power of the consumers (here the NPC companies), decreased the market power of the producers (here the OFS companies). In effect, the less market power the producers have, the flatter the demand curve.

$$B(\gamma) = b_1 - b_2\gamma \tag{B4}$$

For a numerical simulation we let

$n = 5$
$c = 100$
$f_i = 25{,}000$
$b_1 = 1$
$b_2 = 1$
$a_1 = 1000$
$a_2 = 1000$

Again, we allow γ to increase from 0 to 0.30 in increments of 0.01. The drop in profits caused by an increase in bargaining power is lower when the slope also changes, compared with the case with a change intercept only. Both these scenarios are shown in Figure B1.

APPENDIX C

TABLE C1 Effect of market concentration on profits for various concentration measures. Dependent variable is the inverse sine of profit of OFS companies in period *t*

	(1)	(2)	(3)	(4)
π^*_{t-1}: Inverse sine of profit OFS companies *t*−1	0.298*	0.231	0.232	0.209
	(0.172)	(0.190)	(0.200)	(0.241)
HHI_{t-1}: HHI for NPC *t*−1	−0.0043***			
	(0.0015)			
$C3_{t-1}$: NPC market share 3 largest companies *t*−1		−0.0083**		
		(0.0032)		
$C4_{t-1}$: NPC market share 4 largest companies *t*−1			−0.0115**	
			(0.0052)	
$C5_{t-1}$: NPC market share 5 largest companies *t*−1				−0.0164*
				(0.0091)
P^{Oil}_{t-1}: Logarithm of real oil price *t*−1	0.147***	0.163***	0.164***	0.166***
	(0.0271)	(0.0261)	(0.0279)	(0.0298)
V^{Oil}_{t-1}: CV real oil price *t*−1	0.0095***	0.0096***	0.0095***	0.0059***
	(0.002)	(0.0022)	(0.0023)	(0.0014)
n_{t-1}: Number of OFS companies *t*−1	−0.0026***	−0.0035***	−0.0032**	−0.0025**
	(0.0009)	(0.0013)	(0.0013)	(0.0012)
Observations	351	351	351	351
Groups	143	143	143	143
Instruments	13	13	13	13
Time dummies	Yes	Yes	Yes	Yes
GMM instrument lag	1	1	1	1
AR(2) test *p*-value	0.366	0.372	0.375	0.382
Hansen OID test *p*-value	0.270	0.176	0.141	0.105
Underidentification test (Cragg-Donald)				
p-value	0.0002	0.0003	0.0003	0.0005
Test statistic	27.90	27.51	27.07	26.13
Degrees of freedom	7	7	7	7
Underidentification test for regressors (Sanderson-Windmeijer conditional underidentification tests *p*-values)				
HHI_{t-1}: HHI for NPC *t*−1	0.0000			
$C3_{t-1}$: NPC market share 3 largest companies *t*−1		0.0000		
$C4_{t-1}$: NPC market share 4 largest companies *t*−1			0.0000	
$C5_{t-1}$: NPC market share 5 largest companies *t*−1				0.0000

Note: Values in parenthesis are Windmeijer robust standard errors. ***, ** and * indicate significance levels of 10%, 5% and 1% respectively. Intercept and time dummies not reported for brevity. For the Sanderson-Windmeijer tests for underidentification only the *p*-values for the market concentration are reported for brevity.