The effect of R&D on financial performance

A study of Norwegian oilfield service companies

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The effect of R&D on financial performance:
A study of Norwegian oilfield service companies

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Abstract

Investments in research and development (R&D) may enhance competitive advantage and help sustain profitability over time. With access to a unique dataset covering 14 years of accounting data for Norwegian oilfield service companies, we examined whether R&D affects financial performance. Unlike previous research on this topic, we tested for within-industry segment-specific effects and used a broader range of financial performance measures.

Prevailing academic consensus suggest that R&D has a positive effect on financial performance. However, the findings of this paper suggest otherwise. We did not find evidence for a positive effect of R&D on subsequent financial performance. The analysis revealed several segment-specific effects of R&D, but these seem to be a result of bidirectional relationships rather than causality. If any, R&D seems to have a negative impact on asset turnover. Instead, evidence is more robust for a direct relationship between profit margins and subsequent investment in R&D.

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Preface

This master thesis completes our Master of Science in Business Administration, with a specialisation in Applied Finance, at the University of Stavanger. The thesis is written in the format of a research paper, with the ambition of having it published in a scientific journal.

Norwegian oil- and oilfield service companies have been struggling after the oil price plunge in 2014, causing an increased focus on innovation. Investigating the impact of innovation (R&D) on financial performance, therefore, seemed particularly appealing.

Writing this thesis has both been challenging and provided us with knowledge of the financial consequences of R&D and the Norwegian oilfield service industry. We believe this work has provided an experience that will be valuable in our future careers.

We would like to thank our supervisors, Peter Molnár and Svein Olav Krakstad, for their inspiration, guidance, and feedback throughout this semester. Thank you for your availability despite the challenges during the COVID-19 outbreak.

Finally, we would like to emphasise our gratitude to EY for supplying necessary data to conduct this analysis.

1. Introduction

Innovation can be crucial for a business to sustain profitability over time. As demand changes, products and solutions must improve to attract new customers and ensure customer retention. Innovation can also enhance competitive advantage through lower costs and improved internal systems.

The petroleum sector plays a vital role in the Norwegian economy. In 2014, the oil price drop challenged the whole industry. Companies have responded with different strategies. In a capital-intensive industry like the petroleum industry, success is highly dependent on technological solutions. Thus, innovation could be a solution. However, investments in innovation are capital intensive and carry risk as with any other project. Decisions to invest in innovation should, therefore, be analysed carefully.

The topic is once again on the agenda, following the recent oil price drop in early 2020.

We utilised a unique dataset covering the population of Norwegian oilfield service (OFS) companies. Using the fixed effects regression method for firm-level panel data, we investigated the effects of innovation, measured as R&D, on financial performance.

In contrast to the supportive consensus among other researchers, the results in this paper do not provide sufficient evidence to conclude that there exists a direct relationship between R&D and financial performance. Our results suggest bidirectional relationships between the various financial measures and identify vast differences across segments.

The rest of the paper is structured as follows. First, we carry out a comprehensive review of previous research to get better insights into the effects of R&D. We then present the historical development in the Norwegian OFS industry. Section 4 and 5 introduce the dataset and methodology applied in this paper. In section 6, we present the results and a discussion of these. Lastly, we summarise all conclusions in section 7.

2. Previous research

Several researchers have analysed the effects of R&D. The majority finds a positive relationship between R&D and financial performance. However, the results are not consistent enough to be used as a basis for all companies and industries. Further research is necessary to enhance empirical evidence on the financial consequences of R&D.

García-Manjón and Romero-Merino (2012) studied 757 European firms in the period 2003 to 2007 and found that R&D intensity had a positive effect on sales growth. Similar result where found in a recent study by Spescha (2019) who examined the effect of R&D for Swiss manufacturing, construction, and service industries. The researcher found R&D expenditures to be directly related to sales growth for small firms. However, the findings suggested an inverse relationship for large firms. Further results revealed the relationship between R&D expenditures and sales growth to be stronger for industries with many small firms, and weaker for those with fewer but larger firms (Spescha, 2019).

Cefis and Ciccarelli (2005) analysed manufacturing firms and found innovation to have positive, but diminishing, effect on firm profitability. Furthermore, the results showed that innovators tend to have better profitability in the long run (Cefis & Ciccarelli, 2005). Besides, Park, Shin, and Kim (2010) found that R&D increased the probability of survival when they studied South Korean manufacturing companies.

Erdogan and Yamaltdinova (2019) studied production companies from various industries listed on Borsa Istanbul. The researchers found R&D expenditures to be positively related to return on assets (ROA) and return on equity (ROE). The relationship was inversely U-shaped, which means that ROE and ROA increased with R&D intensity (R&D expenditures to sales) at a diminishing rate. Comparable results were found for Taiwan-based information technology and electronic companies by Yeh, Chu, Sher, and Chiu (2010). Ambrammal and Sharma (2016) examined the relationship for manufacturing firms in India. They both found R&D and patenting to have a positive effect on pre-tax profit margin. For productivity, only patenting had a significant positive impact. Tsai and Wang (2004) analysed a balanced dataset of Taiwanese electronic companies and did not find R&D being more substantial for larger companies.

Jefferson, Huamao, Xiaojing, and Xiaoyun (2006) examined the effect of R&D on firm performance in China using panel data from 20,000 large and medium-sized manufacturing companies. They found that R&D intensity has a positive effect on firm performance and new product innovation.

Asthana and Zhang (2006) found that R&D intensity in companies and industries is directly related to the persistence of abnormal earnings. Supporting results were also found by Cozza, Malerba, Mancusi, Perani, and Vezzulli (2012) when they investigated the impact of innovation on economic performance for Italian manufacturing firms. For small- and medium-sized companies, they found a positive "innovation premium" for profitability and growth (in revenue and number of employees). The premium was particularly large for small and newly established firms (Cozza et al., 2012).

Contrary to the papers previously mentioned, Artz, Norman, Hatfield, and Cardinal (2010) found patents to have a negative impact on sales growth and return on assets. Regarding "innovation premiums", Sohn, Hur, and Kim (2010) found inconclusive results on the effect of R&D on profitability for Korean venture firms. However, they did find a direct relationship between R&D and revenue growth.

Firm-level financial ratios are closely related and should be carefully examined. Morbey and Reithner (1990) highlighted this when they investigated the performance of 134 companies from 1978 to 1987 and 727 companies from 1983 to 1987. They presented the following equation, which illustrates a relationship of concern when using ratios to measure financial performance on firm-level:

$$\frac{R\&D}{Employee} = \frac{Sales}{Employee} * \frac{R\&D}{Sales} = Productivity * Research\ intensity$$

Morbey and Reithner (1990) found that R&D per employee is closely related to profit margin, whereas research intensity had an insignificant effect on profit margin. R&D per employee was also strongly related to productivity. Given their findings and the formula mentioned above, R&D per employee captured the effect of productivity. The conclusion was that employee productivity governs profit margins, which is only modified by research intensity (Morbey & Reithner, 1990).

Even though conclusions are not consistent across research papers, the consensus seems to be that R&D has a positive effect on subsequent financial performance. However, several of the researchers seem to include only a few variables and too strict definition of financial performance. Some also seem to neglect the possibility that financial performance impact the decision to invest in R&D.

Examining the effect of R&D on financial performance raises the concern of causal interpretation. There may be a bidirectional relationship since financial performance probably also affect R&D investments. A good understanding of this is essential when constructing the regression models and interpreting the results.

Previous researchers have analysed the characteristics of companies that invest in R&D. For instance, Hitt, Hoskisson, Ireland, and Harrison (1991) found acquisitions negatively related to R&D- and patent intensity, and argues for a capital constraint since both activities are capital intensive. Del Canto and Gonzalez (1999) found that intangible resources such as human and commercial resources are key determinants for the decision to invest in R&D. Coad and Rao (2010) concluded that growth in the number of employees and revenues are directly related to subsequent R&D expenditure. They did not find such relationships for profit growth and subsequent R&D investment (Coad & Rao, 2010).

Xu and Sim (2018) investigated the characteristics of R&D investments across China and South Korea. In both countries, cash holdings had a positive impact on R&D intensity, and debt ratio a negative effect. R&D intensity decreases as the firm size increases in China, while the opposite was the case in South Korea (Xu & Sim, 2018). Jefferson et al. (2006) found that company size, market concentration and profitability drive R&D efforts in Spain. For the US manufacturing and retail sector, Fishman and Rob (1999) found R&D expenditures to be higher for larger firms than smaller ones. For drug and pharmaceutical companies in India, the results showed that firm size had a negative effect on R&D intensity (Tyagi, Nauriyal, & Gulati, 2018). Furthermore, the study found R&D intensity directly related to return on assets and inversely related to the leverage ratio.

For drug and pharmaceutical companies in India, the results showed that firm size negatively impacts R&D intensity (Tyagi et al., 2018). Furthermore, the study revealed leverage to have a negative effect, and return on asset a positive effect on R&D intensity. Comparing these findings with economic reasoning raises the question of whether financial performance is the exogenous rather than the endogenous variable.

Topics like business type and location should be of interest when discussing previous research. As an illustration, Hundley, Jacobson, and Park (1996) found that profitability inversely relates to R&D investments in Japan, while it directly relates to investments in R&D for US firms. These factors could be explained by collaborations across organisations, corporate governance and availability of finances (Hundley et al., 1996). Public incentive schemes could be another explanation. It also makes sense that R&D will impact differently across businesses. One should, for instance, expect a different return from R&D investments in retail than for the communication industry. This discussion highlights the importance of cautious interpretations of empirical results on this topic.

3. The Norwegian oilfield service industry

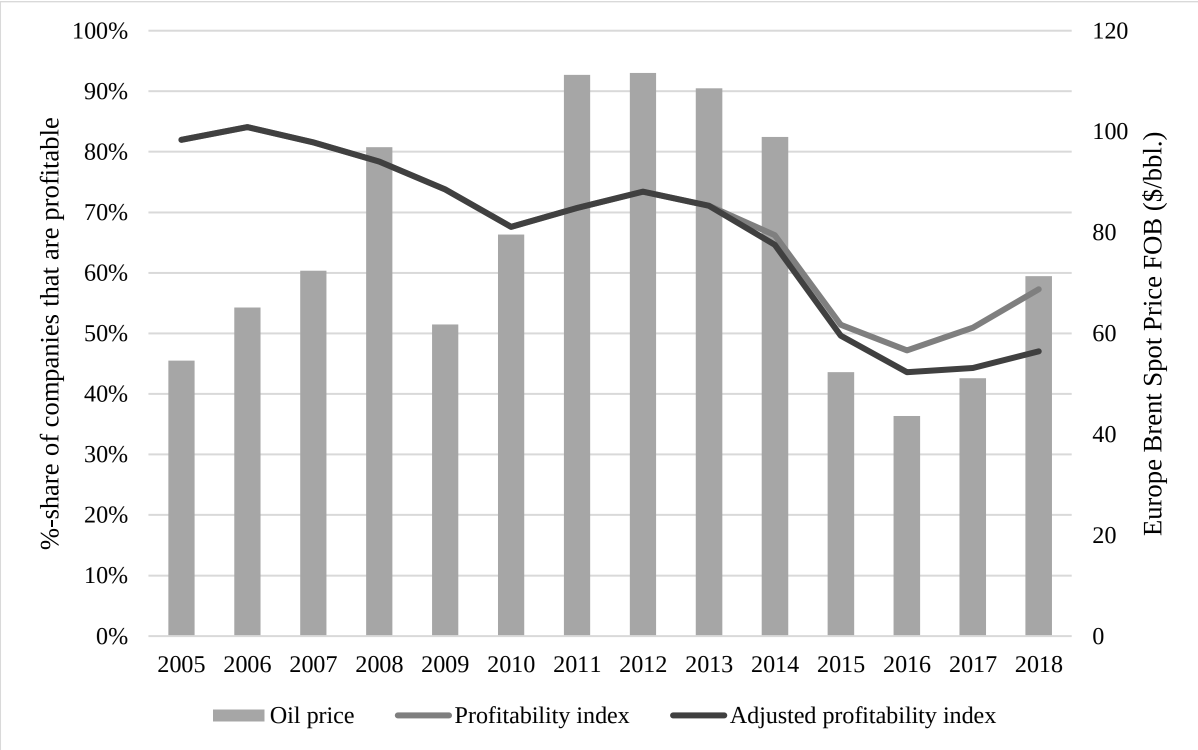
In 2018, the Norwegian oilfield service (OFS) industry consisted of 1136 active companies which served offshore oil and gas companies. They are diverse in their offerings, ranging from drilling rigs and vessels to engineering and consultancy services. The industry consists of five segments: (1) Engineering, fabrication and installation (EFI), (2) Exploration and production drilling (E&P Drilling), (3) Operations, (4) Reservoir and seismic (Seismic), and (5) Decommissioning (EY, 2020). Section 4.2 contains more information about these segments.

The Norwegian OFS industry has faced significant challenges, such as the financial crisis of 2008 and the oil price drop in 2014. Throughout these years, it has become clear that the negotiation power lies with the upstream oil and gas companies. They have re-negotiated contracts with their suppliers and pushed prices lower to maintain margins (Nyman, 2015). Some have even criticised large E&P companies, such as Equinor, for abuse of power (Skarsaune, 2016). OFS companies' lack of control has raised the intriguing question; "What should Norwegian oilfield service companies do to ensure profitability, efficiency, and revenue growth over time?". R&D might be the answer. Better products and services could make OFS companies more attractive to their customers, allowing them to regain negotiation power and customer retention.

Surviving versus non-surviving companies

Figure 1 illustrates how the share of profitable Norwegian OFS companies has decreased over the years. Along with the decline in profitability, the total number of companies has decreased from 1384 to 1136. Bankruptcies have caused a survivor bias to the calculated profitability index. Adjusting for the survival bias, more than half of the firms were unprofitable in 2018, despite an average oil price of 70 USD. In other words, most companies in this industry fail to generate profits to their shareholders. Companies must act differently to remain profitable over time. R&D may be an option to consider if they want to stand out relative to their peers.

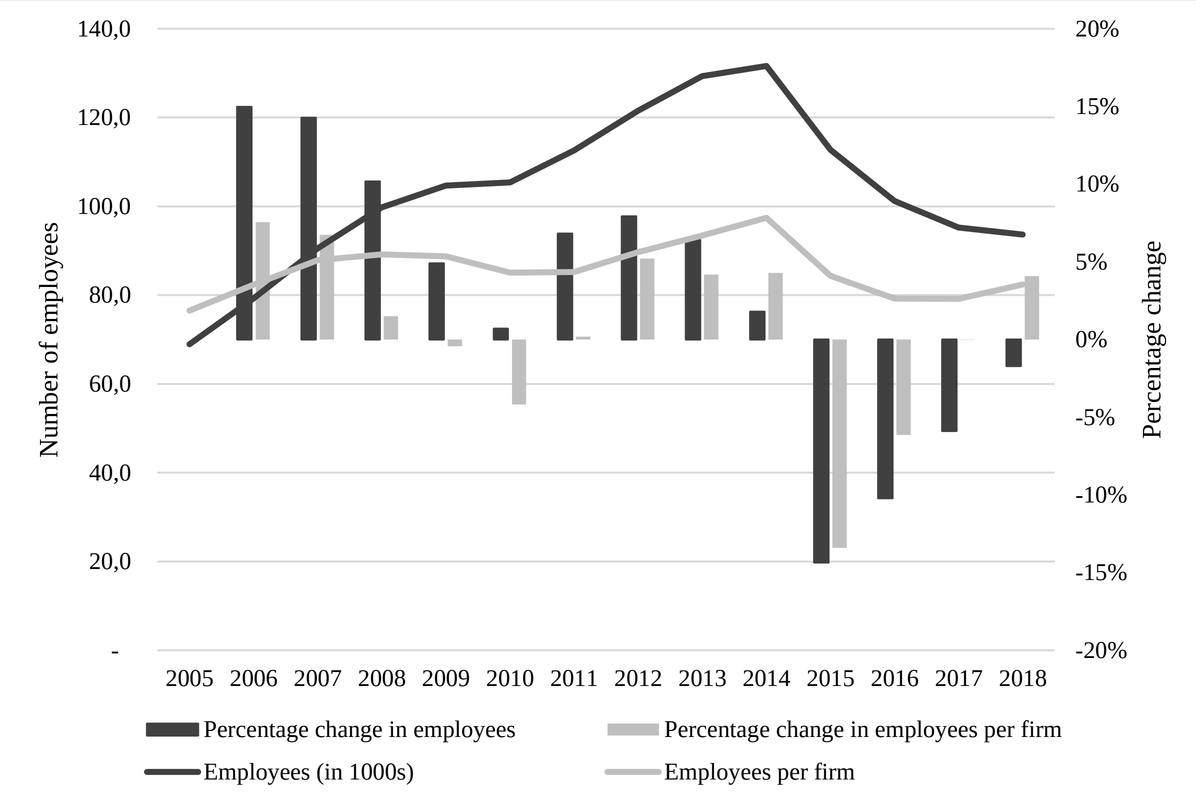
Figure 1: Historical oil prices and development in profitability for the Norwegian OFS industry



Source: Data from U.S. Energy Information Administration (2020) and EY (2020).
Note: Historical Europe Brent Spot Price FOB (Dollars per Barrel, an average of daily prices) and development in the share of profitable Norwegian OFS companies. The profitability index is calculated by dividing the number of profitable companies by the total number of companies (year-end). The adjusted profitability index uses the total number of companies in 2013 in the denominator for the year 2013 to 2018.

In 2018, there seems to exist an interesting distinction between surviving and non-surviving companies. As Figure 2 shows, the total number of employees in the sector decreased, while the number of employees per firm increased. According to our analysis, non-surviving companies are the biggest reason for the decrease in the total number of OFS workers. Consequently, Figure 2 shows that surviving companies are now hiring more people, which is a strong signal of management confidence. The resulting question is, what has been the successful strategy for the companies that are now hiring?

Figure 2: Development of employees in Norwegian OFS companies



Source: Data from U.S. Energy Information Administration (2020) and EY (2020).
Note: Development in the number of employees in the Norwegian OFS industry. The number of employees is the sum for all Norwegian OFS companies. "Employees" is an abbreviation for "number of employees".

External support and financing

The government, through The Research Council of Norway, supports the oil industry with the purpose to ensure a value-adding future. The support aims to develop competence, competitiveness, and safety in the exploration of petroleum resources (Norwegian Petroleum Directorate, 2019). A report by Rystad Energy on behalf of the Norwegian Research Council found that their support adds value for the Norwegian society in several ways, including cost-savings, increased discovered oil-reserves, employment, and competence (Rystad Energy AS, 2020, p. 4).

Another government program, The SkatteFUNN R&D tax incentive scheme, allows for a possible deduction from the companies' payable corporate tax (Forskningsrådet, 2020). Subject to certain conditions, businesses may be entitled to a tax deduction of 18-20 % of their R&D expenses (Skatteetaten, n.d.).

Oil and gas companies and other organisations may rely on innovation in OFS companies. If capital restricts OFS companies' ability to invest in R&D, external partners may be willing to support new ideas in order to see that the concepts go through. Thus, external partners represent a potential source of financing.

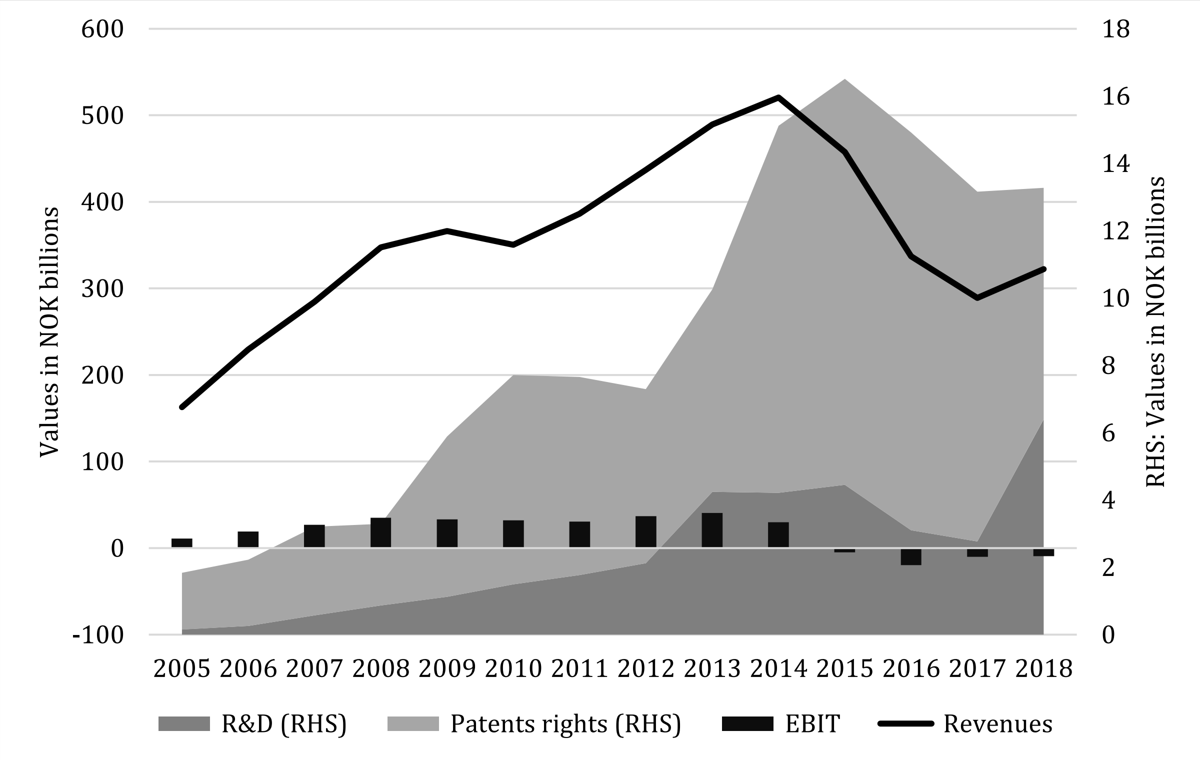
Tax benefits, public support and external financing represents economic benefits that reduces the downside risk of R&D. Consequently, the hypothesis that R&D contributes positively to long term financial performance seems valid.

R&D, profitability, and revenue growth in Norwegian OFS companies

According to The Norwegian Accounting Standards Board, two requirements must be fulfilled for a company to capitalise an intangible asset. First, it must be identifiable, and secondly, the company must control the assets such that they represent expected future economic benefits for that company (Norsk RegnskapsStiftelse, 2012). Balance sheet R&D and patent rights are, therefore, expected to generate future economic benefits.

Figure 3 shows the relationship between capitalised R&D, patent rights, total revenue, and EBIT from 2005 to 2018. The oil price shock in 2014 led to a significant drop in total revenue and EBIT, and a subsequent drop in capitalised R&D and patent rights. Following the price drop in 2014, the level of capitalised R&D and patent rights fell because of impairment, depreciation, fewer investments, and M&A activities.

Figure 3: Historical development in revenues, EBIT, R&D and patent rights



Source: Data from U.S. Energy Information Administration (2020) and EY (2020).
Note: All values are the sum of all Norwegian OFS companies.

Despite the consequences following the oil price drop in 2014, some companies have performed better than others. Could accumulated R&D and patent rights be the reason why some have been able to maintain profits better than others?

4. Data

We obtained the dataset from Ernst & Young AS (EY). The dataset was created in conjunction with the annual "Norwegian oilfield services analysis" (EY, 2020). It consists of the accounting data for 1886 Norwegian OFS companies in the period 2005 to 2018. EY initially retrieved the data from the Brønnøysund Register Centre. OFS companies are defined to have at least 50 % of their revenue generated in the oil and gas sector (EY, 2020). EY has categorised all companies into five segments and 13 sub-segments based on the "value chain segment in which they generate the majority of their revenues" (EY, 2020, p. 27). To alleviate the issues of comparisons over time, EY appraised the segment specifications for each firm every year. For more detailed information on how the data was retrieved and processed, please refer to "The Norwegian oilfield services analysis 2019" (EY, 2020).

The pricing history for Europe Brent Spot Price FOB (US$/bbl.) was retrieved from the U.S. Energy Information Administration (2020).

4.1 R&D identification

The data set contains accounting information for all Norwegian OFS companies. According to the Accounting Act, internal expenses related to R&D may be expensed (Regnskapsloven, 1998, § 5-6) or capitalised (Regnskapsloven, 1998, § 6-2). Expenditures related to patent rights should be capitalised (Regnskapsloven, 1998, § 6-2). The decision to expense R&D is a choice of accounting principle rather than an accounting assessment (Norsk RegnskapsStiftelse, 2012, p. 5). Despite these accounting principles, companies should specify outlay related to R&D in their financial statements (Regnskapsloven, 1998, § 7-14 & § 7-39).

The data set used in this paper does not contain information about R&D booked as an expense in the income statement. Thus, it is not possible to distinguish those who expense R&D from those who do not spend money on R&D. To limit this issue, we removed companies without R&D on the balance sheet in any years. The adjustment increased comparability across firms since the remaining companies follow similar accounting principles. For these companies, investments in innovation were defined as capitalised R&D plus capitalised patent rights. Patent rights and R&D are related, which makes it natural to include both. Patent rights are often a way to ensure ownership of the output from R&D, and thus reflect past activities that have sought to develop better products and solutions.

Several papers have studied the characteristics of firms that capitalise compared to those who expense R&D expenditures. Firms that capitalise R&D are typically smaller, more leveraged, less profitable, and have fewer growth opportunities (Cazavan-Jeny & Jeanjean, 2006). A study by Ballester, Garcia-Ayuso, and Livnat (2003) found that smaller firms in the early stages of the life cycle are more likely to build intangible R&D assets (relative to market value) than larger, more mature firms. Mature firms have already been able to reap the benefits of prior R&D efforts in their profit (Ballester et al., 2003). Hence, excluding companies without any R&D or patent rights on their balance sheets could cause the analysis to focus more on smaller companies in earlier stages of the business life cycle.

For simplicity, we hereafter refer to the sum of balance sheet research and development and patent rights as R&D.

Table 1 shows that the excluded companies have more cash and debt relative to total assets than those kept in the dataset. Companies with R&D on their balance sheet also, on average, have more goodwill to total assets. Furthermore, included companies have higher revenue growth than those excluded. The statistical comparison does not find differences in size between the two groups. Besides, other performance measures are not statistically different for the included and excluded companies. The regression models control for size and capital structure. Thus, the exclusion should not have a material impact on the results.

Table 1: Mean comparison (t-test) of companies with and without R&D.

Variable	**Included (1)**		**Excluded (2)**		**Difference (1-2)**	
	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.
EBIT%	-2.291	0.8332	6.089	5.692	-8.380	7.260
EBITDA%	-1.875	0.7514	2.036	3.424	-3.911	4.389
PROFIT%	-1.869	0.8640	8.806	7.669	-10.68	9.766
ROA	0.0111	0.0068	0.0211	0.0172	-0.0100	0.0225
ROE	0.0860	0.1041	1.970	4.773	-1.884	6.037
GROWTH	10.76	3.691	5.473	0.9846	5.287*	3.176
ATO	1.513	0.0396	3.244	1.029	-1.732	1.304
CASH	0.1958	0.0058	0.2380	0.0061	-0.0423***	0.0090
EMP	0.0007	0.0000	0.0007	0.0001	0.0000	0.0001
SIZE	11.18	0.0632	11.15	0.0693	0.0358	0.0970
DEBT	0.7034	0.0115	0.7816	0.0231	-0.0782**	0.0307
GOODWILL	0.0116	0.0017	0.0038	0.0009	0.0078***	0.0017

Source: Data from EY (2020).

Note: Significance level *** p<0.01, ** p<0.05, * p<0.1. EBIT% and EBITDA% are the EBIT- and EBITDA margin. PROFIT% is net earnings/total revenues. ROA is the return on assets, and ROE is the return on equity. ATO is total revenue/total assets. GROWTH is the growth in total revenues. CASH is cash and equivalents divided by total assets. EMP is the number of employees divided by total assets. SIZE it the logarithmic value of total assets. DEBT is total debt to total assets. GOODWILL is goodwill to total assets. "Included" represents the companies with R&D on their balance sheet, and "excluded" are those without capitalised R&D. “Std. Err.” is short for standard error. Before conducting the t-tests, we converted the panel data to a pooled dataset by taking the average of yearly values for all companies.

4.2 The Norwegian OFS segments

This paper analyses the financial effects of R&D on segment level using the same five segments as the annual "Norwegian oilfield service analysis" compiled by EY (2020). Table 2 is a tabular summary of all segments along with a brief description, an overview of sub-segments, the total number of Norwegian OFS companies in each segment and the segments' market concentration, measured as the Herfindahl-Hirschman Index (HHI). Please refer to Appendix 1 for a more detailed description of all segments.

Table 2: Tabular summary of segment characteristics

#	Segment	Short description	Sub-segments	Companies*	HHI
1	Engineering, fabrication & installation	Equipment supply, construction, manufacturing, and installation of production units on surface and subsea	Consultants and engineering houses, shipyard, subsea, workshops & product suppliers designs, yards/lager EPCI	562	262
2	Exploration & production drilling	Provides skilled personnel and consultants to both upstream- and oilfield service companies	Rig companies, rig equipment, well services	198	475
3	Operations	Supports upstream oil companies in the production	Maintenance & modifications, offshore logistics	317	146
4	Reservoir/seismic	Operates seismic vessels, analyse, consult, interpret and/or display data, and related suppliers.	Reservoir and seismic	53	1116
5	Decommissioning	Decommissioning of offshore installations	Decommissioning	6	5087

Source: Data and segment descriptions from EY (2020).

Note: Companies is the total number of companies in the segment as of year-end 2018. HHI is the calculated Herfindahl-Hirschman Index based on Norwegian OFS companies' revenues in 2018, ranging from 0 to 10 000. A lower number indicates lower market concentration (U.S. Department of Justice, 2018). *Includes all companies in the dataset, before adjusting for accounting principles as described in section 4.1.

Markets with HHI between 1500 and 2500 are moderately concentrated (U.S. Department of Justice, 2018). Engineering, fabrication & installation (EFI), Exploration & production drilling (E&P Drilling), Operations, and Reservoir/seismic (Seismic) have low market concentration, i.e. high competition. The opposite is the case for Decommissioning, which is a highly concentrated marketplace with only six companies.

Table 3 presents a summary of the 2018 common-size financial statements for the five segments. The financial figures reveal apparent differences between them. For instance, EFI and Decommissioning have a considerably higher cost of goods sold than the other OFS segments. The segment Operations has the highest level of personnel costs, which stand in contrast to Seismic with the lowest. Other operating costs are highest in E&P Drilling.

Seismic stands out with the highest-level of EBITDA margin and is the only segment with a positive EBIT margin. It also has the highest level of R&D.

EFI, E&P Drilling and Decommissioning have less tangible assets (to total assets) than Operations and Seismic. The Operations segment has the highest degree of tangible assets and second-lowest R&D to assets, which is quite contrary to the capital structure for Seismic.

Table 3: Common size financial figures for the Norwegian OFS segments

*Fiscal year 2018**	EFI	E&P Drilling	Operations	Seismic	Decomm-issioning
Number of firms	*562*	*198*	*317*	*53*	*6*
Employees per firm	*92*	*95*	*67*	*25*	*42*
Revenues (in bill. NOK)	160,3	87,6	55,4	18,1	1,0
Cost of goods sold	54 %	21 %	24 %	21 %	47 %
Personnel expense	29 %	28 %	37 %	12 %	27 %
Other operating costs	17 %	46 %	29 %	33 %	28 %
EBITDA	1 %	4 %	10 %	34 %	-1 %
Depreciation	2 %	4 %	9 %	30 %	2 %
Impairment	0 %	3 %	7 %	1 %	0 %
EBIT	-2 %	-3 %	-7 %	3 %	-4 %
Total assets (in bill. NOK)	232,8	147,4	137,8	46,5	0,5
Total debt	60 %	69 %	79 %	59 %	93 %
R&D	1,7 %	0,9 %	0,3 %	16,6 %	0,1 %
Tangible assets	9 %	21 %	49 %	43 %	16 %

Source: Data from (EY, 2020).

Note: Values are the sum for all companies in the corresponding segment. R&D = sum of R&D and patent rights. Percentages from "cost of goods sold" to "EBIT" are in % of total revenues. "Total debt" to "Tangible assets" are in % of total assets. *Includes all companies in the dataset, before adjusting for accounting principles as described in section 4.1.

Due to the differences in business offerings and financial figures, we expect differences in the effect of R&D investments on financial performance. Thus, this paper tests for segment-specific effects.

4.3 Descriptive statistics and presentation of variables

This section presents all variables used in the regressions. Table 4 presents the segment dummy variables and the number of observations for each segment. The far-left column shows the variable name that appears in the regression output. As an example, SEG2 is 1 for companies that belong in E&P Drilling, 0 otherwise.

Table 4: Presentation of the segment dummy variables.

Variable	Segment	Observations	%-share
SEG1	Engineering, fabrication & installation	3598	54 %
SEG2	Exploration & production drilling	1221	18 %
SEG3	Operations	1400	21 %
SEG4	Reservoir/seismic	417	6 %
SEG5	Decommissioning	40	1 %
Total		6676	100 %

Source: Data from EY (2020).
Note: "Variable" represents each "Segment". %-share represents the segments share of total observations.

Table 5 presents all variables used in the regression models, along with a short description, definition, the number of observations, mean, median and standard deviation (SD).

This paper uses R&D as a ratio to assets. R&D is a balance sheet item. Consequently, it is more appropriate to use total assets in the denominator. Thus, other variables, except for margins and oil price, were also converted into ratios with total assets as the denominator.

Table 5: Descriptive statistics and the definition of variables.

Variable	Description	Definition	Obs.	Mean	Median	SD
EBIT%	EBIT margin	$\frac{\text{EBIT}}{\text{Revenues}}$	6676	-1.793	0.040	49.33
EBITDA%	EBITDA margin	$\frac{\text{EBITDA}}{\text{Revenues}}$	6676	-1.471	0.061	47.83
PROFIT%	Profit margin	$\frac{\text{Net earnings}}{\text{Revenues}}$	6676	-1.463	0.029	43.26
ROA	Return on assets	$\frac{\text{Net earnings}}{\text{total assets}}$	5996	0.027	0.046	1.907
ROE	Return on equity	$\frac{\text{Net earnings}}{\text{total equity}}$	5992	0.249	0.152	5.911
GROWTH	Revenue growth	$\frac{\text{Revenues}_t}{\text{Revenues}_{t-1}}-1$	6002	4.439	0.086	130.5
ATO	Asset turnover	$\frac{\text{Total revenues}}{\text{end of year total assets}}$	6669	1.528	1.369	1.238
OIL	Oil price	Europe Brent Spot Price FOB, (US$/bbl.). Avg. of daily prices.	6676	78.29	72.44	23.73
CASH	Cash to assets	$\frac{\text{end of year total cash \& equivalents}}{\text{end of year total assets}}$	6669	0.189	0.111	0.206
EMP	Employees to assets	$\frac{\text{end of year number of employees}}{\text{end of year total assets}}$	6668	0.001	0.001	0.004
SIZE	Size of the company	Log(end of year total assets)	6669	11.08	10.92	1.920
DEBT	Debt to assets	$\frac{\text{end of year total debt}}{\text{end of year total assets}}$	6669	0.845	0.706	3.581
GOODWILL	Goodwill to assets	$\frac{\text{end of year goodwill}}{\text{end of year total assets}}$	6669	0.011	0.000	0.051
RDP	R&D and patent rights	Capitalised R&D$_t$ + Capitalised patent rights$_t$	6676	18331	27	171676
ΔR&D	New R&D investments	$100 * \frac{\text{RDP}_t - \text{RD.P}_{t-1}}{\text{Total assets}_{t-1}}$	5996	2.208	0.000	29.44
R&D	RDP to total assets	$100 * \frac{\text{End of year RDP}}{\text{end of year total assets}}$	6669	5.208	0.052	12.02
SEG S	Dummy for segment S	Dummy variable for each segment S= (1, 2, 3, 4, 5)	-	-	-	-

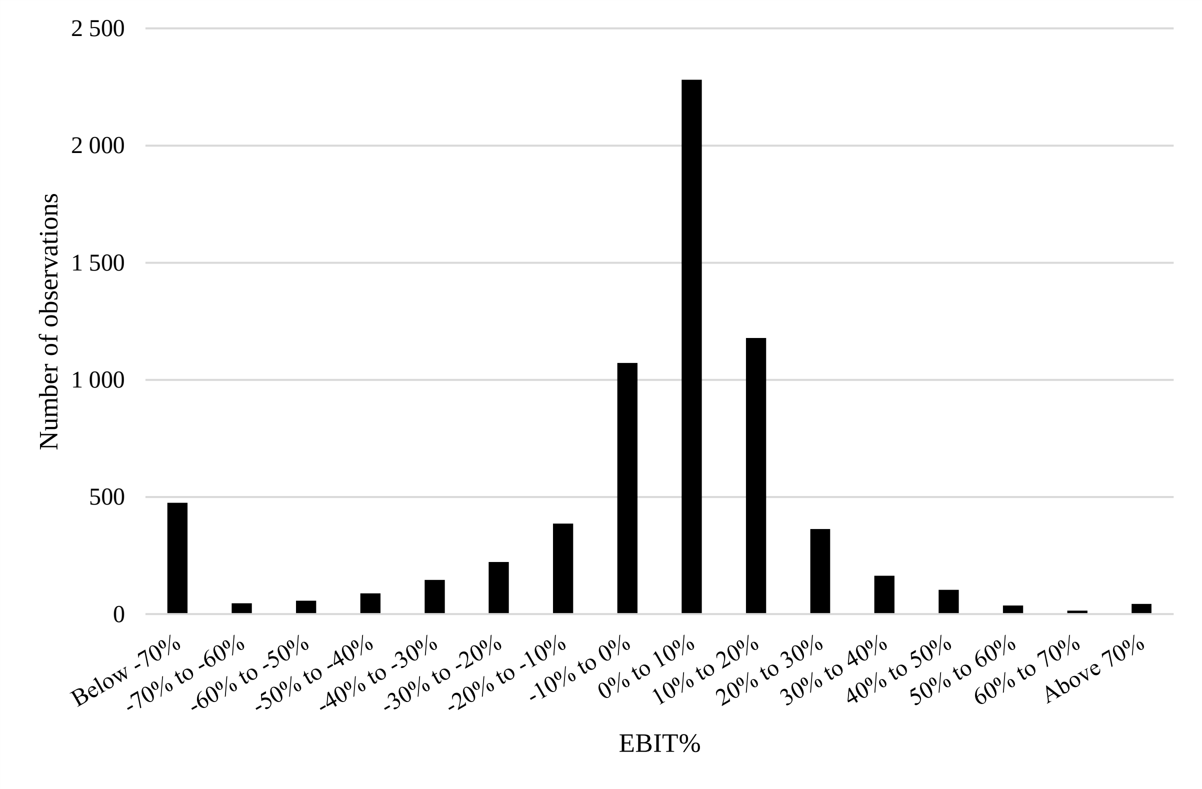
Source: Data from U.S. Energy Information Administration (2020) and EY (2020).
Note: Obs. Is an abbreviation for the total number of observations and SD for standard errors.

Most of the profitability measures have a negative skewness, except for ROE. In addition, GROWTH and ATO is positively skewed. Standard deviation is high for several variables. The variations are high due to differences across units (firms), illustrating the importance of controlling for company-specific effects.

Relative standard deviation (SD multiplied by 100, divided by the mean) is highest for EBIT%. The reason for this unusually high standard deviation and negative skewness is the relatively high number of extreme values, as shown in Figure 4. Figure 5 shows the distribution of size measured as total revenues in the dataset. Figure 6 shows the distribution of revenue growth in the dataset. As these three figures illustrate, the dataset consists of a large share of small companies, in which some have low revenues and significant losses, causing the average EBIT margin to be abnormally low. Later, several of these companies have realised substantial revenue growth which then has normalised the profitability measures. In the regressions, we use a log-transformed measure of size, namely the logarithmic value of total assets, to adjust for some of the skewness. Furthermore, we control for other firm-specific time-varying variables to reduce this issue.

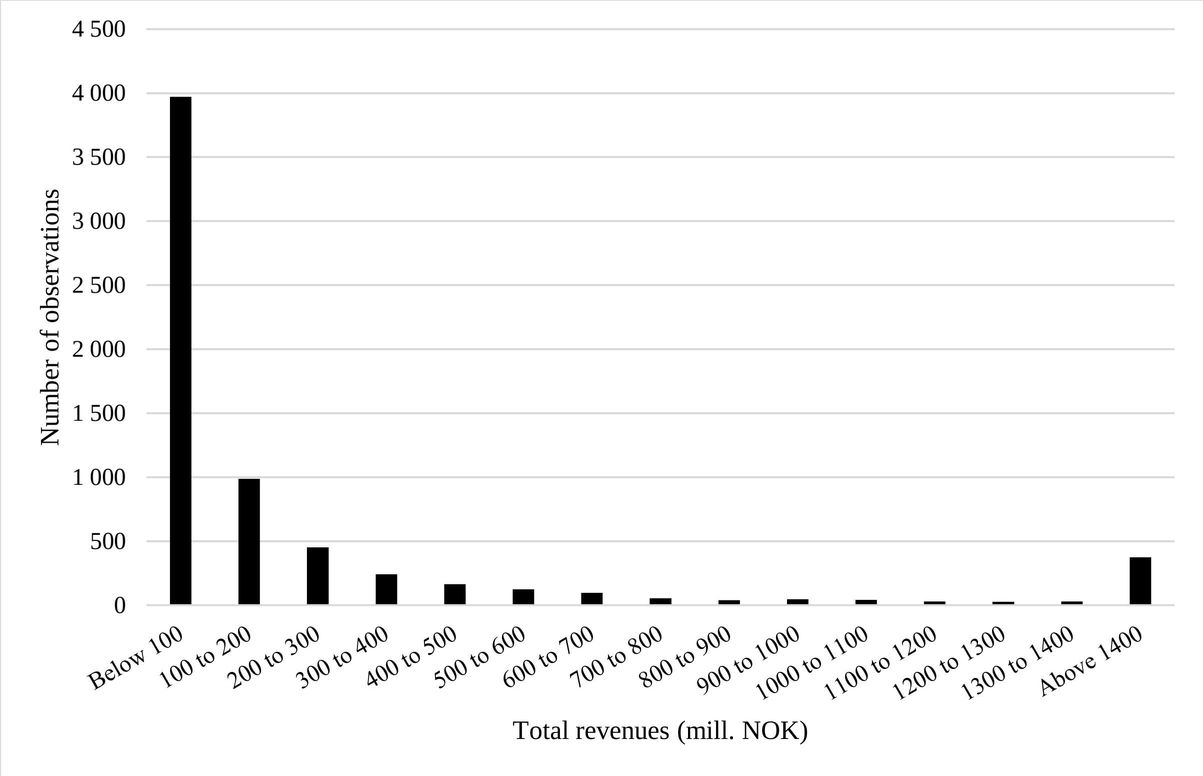
Table 6 presents a correlation matrix for all firm-specific time-varying variables used in the analysis. The results reveal several occasions of statistically significant correlation between the variables. However, the correlation appears to be rather low for most of them.

Figure 4: EBIT margin distribution of observations.



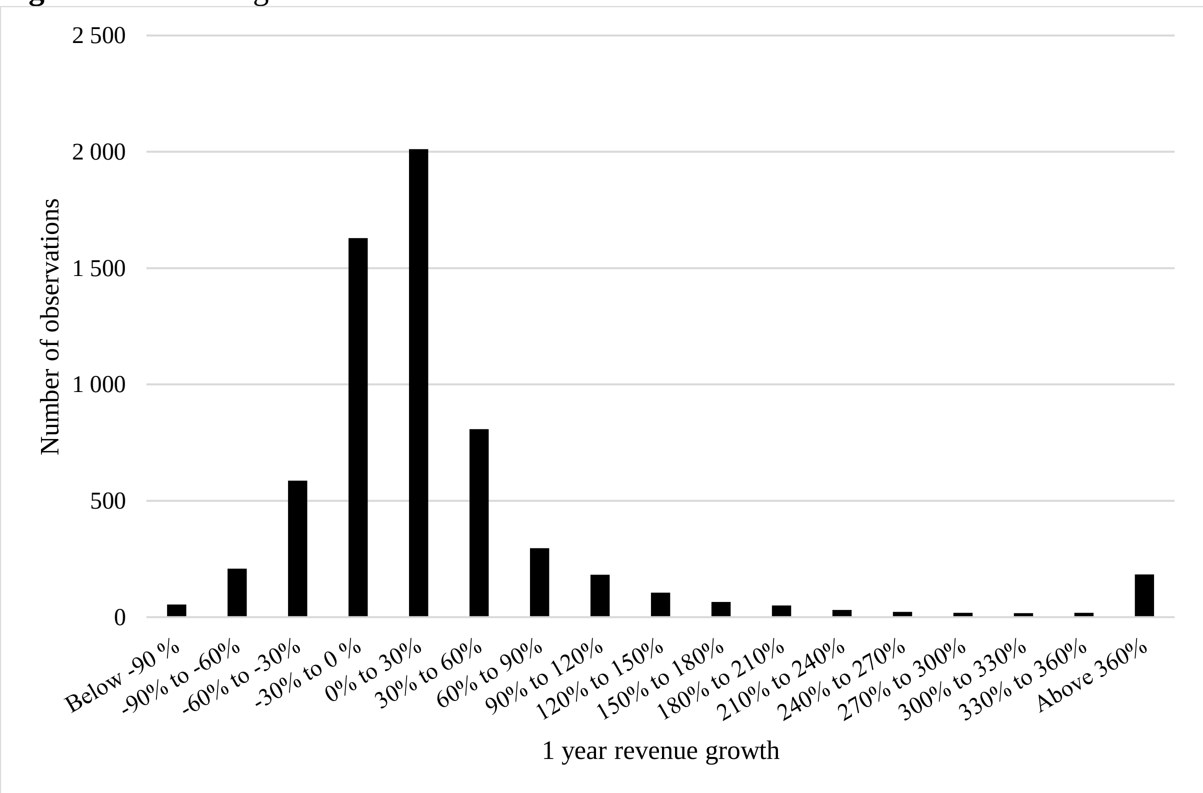
Source: Data from EY (2020).
Note: EBIT% = EBIT/total revenues. Yearly observations.

Figure 5: Revenue distribution of observations.



Source: Data from EY (2020).
Note: Yearly observation

Figure 6: Revenue growth distribution of observations.



Source: Data from EY (2020).
Note: Revenue growth = Percentage change in total revenue. Yearly observations.

Table 6: Within-correlation matrix.

	R&D	EBIT%	EBITDA%	PROFIT%	ROA	ROE	ATO	GROWTH	CASH	EMP	SIZE	DEBT	GOOD-WILL
R&D	1.000												
EBIT%	0.007	1.000											
EBITDA%	0.023*	0.021*	1.000										
PROFIT%	0.029**	0.078***	0.876***	1.000									
ROA	-0.001	0.577***	0.007	0.016	1.000								
ROE	0.010	0.012	-0.013	-0.011	0.035***	1.000							
ATO	-0.075***	-0.167***	0.009	0.011	-0.043***	0.014	1.000						
GROWTH	-0.011	0.001	0.021*	0.022*	0.016	-0.004	-0.016	1.000					
CASH	-0.220***	-0.044***	0.013	0.001	0.011	-0.009	0.053***	-0.004	1.000				
EMP	-0.038***	-0.056***	0.005	-0.032***	-0.010	-0.014	0.188***	-0.001	0.046***	1.000			
SIZE	0.132***	0.155***	-0.007	-0.009	0.078***	0.006	-0.307***	-0.013	-0.154***	-0.066***	1.000		
DEBT	-0.026**	-0.728***	-0.008	-0.051***	-0.398***	-0.005	0.324***	0.001	0.050***	-0.110***	-0.223***	1.000	
GOODWILL	-0.006	0.002	0.000	0.001	-0.003	0.002	-0.020	-0.010	-0.076***	-0.000	0.040***	-0.011	1.000

Source: Data from EY (2020).

Note: Significance level *** p<0.01, ** p<0.05, * p<0.1. R&D is the sum of capitalised R&D and patent rights divided by total assets. EBIT% and EBITDA% are the EBIT- and EBITDA margin. PROFIT% is net earnings/total revenues. ROA is the return on assets, and ROE is the return on equity. ATO is total revenue/total assets. GROWTH is the growth in total revenues. CASH is cash and equivalents divided by total assets. EMP is the number of employees divided by total assets. SIZE it the logarithmic value of total assets. DEBT is total debt to total assets. GOODWILL is goodwill to total assets.

5. Methodology

In this study, we analyse panel data using fixed effects regressions. The dataset is an unbalanced panel since some companies have been established, acquired, merged and gone bankrupt. To avoid losing data due to panel imbalance, we used the statistical software Stata.

We study the effect of companies' R&D investments on their financial performance utilising various measures of financial performance. Since our primary concern is within-effects of time-varying explanatory variables, fixed effects (FE) is usually the appropriate and preferred method. Nevertheless, we carried out all regressions using both FE and RE (random effects) method. We then tested for statistically significant differences in coefficients for all the time-varying explanatory variables using the test first proposed by Hausman (1978). For most of the regressions, the Hausman-test concluded that the FE method was significantly better. For the tests which failed to reject the null hypothesis, both coefficients were sufficiently close. Overall, the tests indicated that FE was the preferred method. For the sake of brevity, we do not report the test results and regressions with RE.

The Wooldridge test was conducted to test for autocorrelation and the Breusch-Pagan Lagrange-multiplier test for heteroskedasticity (Breusch & Pagan, 1979; Wooldridge, 2010). The tests revealed both autocorrelation and heteroskedasticity in the dataset. Thus, we report the regressions with robust standard errors.

5.1 Model specifications

To conclude on the research question, we constructed two models. Model 1 investigated the effect of R&D on financial performance, while Model 2 examined whether there exists a relationship in the opposite direction.

Model 1 – The effect of R&D and patent rights on financial performance

The first analytical model was specified to test the impact of R&D investments on financial performance:

$$Y_t = \alpha + \beta_1(SEG\ S * R\&D_{t-1}) + \beta_{x+1}x_{t-1} + u_t$$

where Y is the dependent variable measuring financial performance, $SEG\ S$ is the segment dummy variable, x_{t-1} refer to the control variables x = (1, 2, …, 6), and t is the time index.

R&D was multiplied to the segment dummy to account for segment-specific effects. Section 5.2 presents the six control variables.

The model was specified in 7 ways with Y representing the following dependent variables: (1) EBIT%, (2) EBITDA%, (3) PROFIT%, (4) ROA, (5) ROE, (6) ATO and (7) GROWTH. We repeated all regressions without segment specifications to illustrate the relevance of dummy variables.

In order to identify the optimal number of lags for the independent variables, several model specifications were analysed. The model with a one-year lag of dependent variable proved superior to other model specifications.

Model 2 – The effect of financial performance on R&D investments

Contrary to the first model, this model test whether financial performance impacts the decision to invest in R&D. The conclusion from this analysis affects the causal interpretation of the results in Model 1. Model 2 was specified using net investments in R&D:

$$\Delta R\&D_t = \alpha + \beta_1 (SEG\ S * X_{t-1}) + \beta_{x+1} x_{t-1} + u_t$$

The new dependent variable is $\Delta R\&D_t$. The variable X represent the financial performance measures. Control variables x = (1, 2, …, 6) are the same as in Model 1.

5.2 Control variables

We included six control variables in addition to the fixed effects imposed by the FE-method:

1) OIL (Europe Brent Spot Price FOB, Dollars per Barrel):
2) CASH (cash & equivalents/assets)
3) DEBT (total debt/assets)
4) EMP (number of employees/assets)
5) SIZE (log(assets))
6) GOODWILL (goodwill/assets)

The control variables were chosen based on previous research findings along with economic reasoning.

Controlling for the oil price is essential since OFS companies' customers are heavily dependent on this commodity price. If the oil price is low, E&P companies will put pressure on the OFS companies, causing profitability and growth to decline. The Norwegian OFS companies in the dataset operate on the Norwegian Continental Shelf. We, therefore, chose to include the Europe Brent Spot Price FOB (Dollars per Barrel) as a control variable.

A capital constraint may put pressure on companies' ability to invest. Hence, cash to assets (CASH) and debt to assets (DEBT) are essential control variables. Findings from Xu and Sim (2018) and Tyagi et al. (2018) support the inclusion of these variables.

The EMP variable is relevant since the number of employees may be closely related to R&D. With the findings of Coad and Rao (2010), this seems evident. Controlling for the number of employees also reduces the risk of interference from productivity, which Morbey and Reithner (1990) identified to be of particular importance.

R&D is usually capital intensive, leaving larger firms more likely to afford such investments. Furthermore, they may also have the capacity to continue daily operations while doing R&D. Fishman and Rob (1999), Park et al. (2010), and Tsai and Wang (2004) found company size related to investment decisions. Hence, SIZE is considered a reasonable control variable. In addition, the negative skewness in the dataset and high standard deviation in both size and profitability highlights the importance of controlling for size. Based on a statistical analysis of the data distribution, we chose to define SIZE as the logarithmic value of total assets.

Hitt et al. (1991) found acquisitions to be negatively related to R&D investments with the conclusion of both activities being capital intensive. GOODWILL, which is a result of previous M&A activities, was therefore included.

6. Results

This chapter presents the results and discuss the implications of these.

6.1 Model 1 - The effect of R&D on financial performance

Table 7 presents the results from Model 1. Overall, R&D seems to have limited effect on subsequent financial performance in the Norwegian OFS industry. There are, however, segment-specific effects and evidence for lower asset turnover for those who had previously invested more in R&D.

In line with the initial hypothesis, R&D investments impacted profitability and revenue growth differently across segments:

- Companies in the EFI segment (SEG1) that have invested more in R&D have, on average, performed worse than other companies in terms of return on assets and asset turnover.
- Within the E&P Drilling segment (SEG2), R&D had a statistically significant and negative impact on asset turnover.
- At 10% significance level, R&D was positively related to EBITDA margin in the Operations segment (SEG3).
- For Seismic (SEG4), R&D had a statistically negative effect on ROA, at 10 % significance level.
- The results indicate that R&D was positively related to PROFIT% in the Decommissioning segment (SEG5).

The results for the Operations and Seismic segments are not strong enough to draw conclusions. 10 % significance level involves a rather high probability of false conclusions. Besides, if R&D inversely impacts ROA in Seismic and has a direct effect on EBITDA margins in Operations, one should expect similar results for other, highly correlated, profitability measures. Since such effects were insignificant, one could question whether the results mentioned were randomly determined. Hence, there is no clear evidence for a causal relationship between R&D and financial performance in either of these two segments.

Within Decommissioning, results suggest that PROFIT% increase with R&D, while R&D did not have a significant effect on EBIT%. One explanation might be tax benefits following such investments, as described in section 3. Significant results for profit margin can also be a coincident as the number of observations was particularly low.

In the EFI and E&P Drilling segments, R&D investments seem to result in subsequent lower asset turnover. The results were similar for the analyses without segment-dummies. Hence, the results suggest a negative relationship between the two variables.

The control variables yielded two notable results. Firstly, higher oil price resulted in subsequent higher asset turnover. However, we did not find such evidence for oil price on subsequent profit margins and revenue growth. These results are counterintuitive. Higher revenue per asset indicates higher activity in the sector when the oil price increases. Despite this, revenue and profitability did not increase, indicating that higher oil price does not result in added value for the OFS companies. The surprising findings may be due to the negotiation power of upstream oil and gas customers. However, several other factors may explain the inconclusive relationship between oil price and next year's financial performance:

- The oil price affects OFS companies differently. When constructing this model, we tested for various combinations of lags, but the one-lag model proved to be superior.
- The complexity of this industry could affect the result. There are vast company-specific differences and considerable variation in profit margins.
- Norwegian OFS companies have been able to adapt: Profit margins are on average unaffected by the oil price.
- Up to 50 % of the revenues can be from less oil price-sensitive industries, which could cause insignificant results.

The second result we want to highlight is the effect of size and cash on asset turnover, which were both statistically significant at 1 % level. When controlling for segment-specific R&D, OIL, EMP, DEBT and GOODWILL, larger firms and those with more cash to assets had on average lower asset turnover in the subsequent period.

The results of this analysis stand in contrast to the supportive consensus among other researchers. Whereas Morbey and Reithner (1990), Park et al. (2010) and Cozza et al. (2012) found R&D results in subsequent growth, we did not find any significant relationship between R&D and subsequent revenue growth either at industry- or segment level. In addition, the results do not suggest an innovation premium for profitability, as found in several research papers (Asthana & Zhang, 2006; Cozza et al., 2012). Instead, the results are more similar to those found by Morbey and Reithner (1990) and Sohn et al. (2010). The findings provide some input to the relevance of productivity discussed by researchers such as Morbey and Reithner (1990) and Tsai and Wang (2004). They suggest that productivity may (Morbey & Reithner, 1990) or may not (Tsai & Wang, 2004) impact the realised return of R&D, while we suggest that R&D impact how efficient the companies utilise their assets (ATO). Our results show that R&D is no silver bullet for financial performance.

Given these results, Norwegian OFS companies should be careful to expect severe value creation from R&D investments as there exist no clear-cut financial advantages. Even when control variables were excluded from the model (see Appendix 2), we did not find evidence suggesting that R&D investments improve subsequent financial performance. If any, such investments cause asset turnover to decrease.

Table 7: Regression output for Model 1.

VARIABLES	(1) EBIT%$_t$	(2) EBIT%$_t$	(3) EBITDA%$_t$	(4) EBITDA%$_t$	(5) PROFIT%$_t$	(6) PROFIT%$_t$	(7) ROA$_t$	(8) ROA$_t$	(9) ROE$_t$	(10) ROE$_t$	(11) ATO$_t$	(12) ATO$_t$	(13) GROWTH$_t$	(14) GROWTH$_t$
R&D$_{t-1}$	0.136		0.140		0.097		-0.002		0.006		-0.005***		-0.028	
	(0.179)		(0.158)		(0.160)		(0.002)		(0.008)		(0.001)		(0.107)	
SEG1 * R&D$_{t-1}$		0.542		0.475		0.414		-0.006**		0.024		-0.010***		-0.090
		(0.507)		(0.437)		(0.396)		(0.003)		(0.016)		(0.002)		(0.112)
SEG2 * R&D$_{t-1}$		-0.191		-0.083		-0.333		0.002		0.011		-0.006***		-0.080
		(0.152)		(0.124)		(0.219)		(0.004)		(0.013)		(0.002)		(0.094)
SEG3 * R&D$_{t-1}$		0.189		0.125*		0.363		-0.003		-0.005		-0.002		0.245
		(0.123)		(0.071)		(0.277)		(0.003)		(0.008)		(0.003)		(0.273)
SEG4 * R&D$_{t-1}$		0.004		0.022		-0.005		-0.003*		-0.014		0.001		-0.176
		(0.033)		(0.030)		(0.029)		(0.002)		(0.013)		(0.003)		(0.147)
SEG5 * R&D$_{t-1}$		4.914		4.749		11.23***		-0.005		-0.188		0.001		-1.434
		(6.314)		(5.337)		(1.950)		(0.028)		(0.250)		(0.0476)		(2.222)
OIL$_{t-1}$	0.046	0.046	0.047	0.0477	0.032	0.032	-0.000	-0.000	0.002	0.002	0.002***	0.002***	0.058	0.058
	(0.053)	(0.054)	(0.053)	(0.053)	(0.042)	(0.042)	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.001)	(0.058)	(0.059)
CASH$_{t-1}$	7.918	8.010	8.940	9.034	5.296	5.457	0.266	0.268	-0.208	-0.194	-0.349***	-0.354***	-7.274	-7.140
	(5.929)	(6.016)	(6.600)	(6.687)	(5.193)	(5.171)	(0.283)	(0.284)	(0.480)	(0.483)	(0.076)	(0.076)	(6.470)	(6.516)
EMP$_{t-1}$	243.4*	220.1	-7.598	-25.08	401.6*	376.8*	-24.48	-24.21	50.83	50.63	8.999	9.070	-31.03	-34.12
	(141.5)	(134.3)	(16.80)	(24.70)	(237.2)	(225.1)	(35.26)	(35.16)	(33.03)	(33.03)	(8.234)	(8.295)	(117.9)	(121.0)
SIZE$_{t-1}$	-0.848	-0.919	-0.789	-0.839	-0.779	-0.834	0.161	0.162	-0.074	-0.077	-0.154***	-0.153***	-3.609	-3.643
	(1.059)	(1.100)	(0.974)	(1.010)	(1.136)	(1.163)	(0.238)	(0.239)	(0.137)	(0.138)	(0.026)	(0.026)	(5.018)	(5.037)
DEBT$_{t-1}$	0.313	0.286	0.000	-0.018	0.532	0.499	0.123	0.124	0.026	0.026	0.015	0.015	-0.177	-0.186
	(0.221)	(0.212)	(0.060)	(0.068)	(0.365)	(0.347)	(0.076)	(0.076)	(0.021)	(0.020)	(0.014)	(0.014)	(0.311)	(0.318)
GOODWILL$_{t-1}$	3.676	1.901	3.957	2.588	2.761	0.781	0.068	0.071	2.472	2.331	-0.384	-0.340	-49.12	-50.93
	(3.262)	(2.624)	(3.502)	(2.681)	(2.613)	(2.556)	(0.266)	(0.267)	(2.973)	(2.942)	(0.396)	(0.357)	(54.47)	(54.70)
Constant	1.346	2.012	1.140	1.563	2.389	2.914	-1.860	-1.869	0.833	0.854	3.145***	3.141***	42.55	42.94
	(6.815)	(7.162)	(5.051)	(5.382)	(10.75)	(10.99)	(2.677)	(2.682)	(1.530)	(1.535)	(0.306)	(0.306)	(53.71)	(53.96)
Observations	5,995	5,995	5,995	5,995	5,995	5,995	5,995	5,995	5,990	5,990	5,993	5,993	5,353	5,353
R-squared	0.002	0.004	0.002	0.003	0.003	0.008	0.035	0.035	0.001	0.002	0.032	0.034	0.001	0.001
Number of id	616	616	616	616	616	616	616	616	616	616	615	615	609	609

Note: Robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1. R&D is the sum of capitalised R&D and patent rights divided by total assets. EBIT% and EBITDA% are the EBIT- and EBITDA margin. PROFIT% is net earnings/total revenues. ROA is the return on assets, and ROE is the return on equity. ATO is total revenue/total assets. GROWTH is the growth in total revenues. CASH is cash and equivalents divided by total assets. EMP is the number of employees divided by total assets. SIZE it the logarithmic value of total assets. DEBT is total debt to total assets. GOODWILL is goodwill to total assets. OIL = Europe Brent Spot Price FOB.

6.2 Model 2 – The effect of financial performance on R&D investments

The second model tested whether past financial performance matters for the decision to invest in R&D. Table 8 presents the regression outputs. In line with previous research, the results revealed that financial measures have an impact on R&D investments. However, the effects were rather diverse across segments:

- EBIT- and EBITDA margin was directly related to R&D investments for companies in the EFI segment (SEG1).
- Within the E&P Drilling segment (SEG2), R&D investments were not found to be determined by past financial performance.
- In Operations (SEG3), prior EBIT margin and asset turnover were inversely related to subsequent R&D investment, while profit margin was directly related.
- For Seismic (SEG4), profit margin had a positive impact on R&D investment.
- Companies in Decommissioning (SEG5) with higher revenue growth, on average, invested less in R&D the following year.

Some of the results were conflicting. For instance, higher EBIT margin had a positive effect on R&D investments in the EFI segment, but a negative effect in the Operations segment, both statistically significant at 10%. Economically speaking, it is possible to defend both. Profitable companies may have a more robust cash flow to rely on, and are thus able to invest more. On the other hand, unprofitable companies may invest more in R&D in order to come up with more financially sustainable solutions. Which of the two dominates may be dependent on average profitability in those segments. Even though they may seem conflicting, it is not possible to say that one or more of them are wrong.

It is more challenging to interpret the different effects of EBIT- and profit margins in the Operations segment. When controlling for debt and other relevant variables, the main difference between EBIT and net earnings is tax expenses. If a company has previously invested in R&D, it may have received a tax deduction. Consequently, the profit margin may be higher relative to the EBIT margin than other companies that have not received such benefits. Accordingly, the results can be interpreted such that Operations-companies that have previously received tax benefits invest more than other companies in R&D. Asset turnover was inversely related to R&D investments in this segment. Thus, it seems like companies in the Operations segment that operates less efficiently, have lower profitability (EBIT%) and have previously received tax deductions invest more in R&D. Accordingly, the results may imply that firms who have previously invested in R&D tend to invest more in R&D than others in the future.

We did not find any evidence for financial performance affecting the decision to invest in R&D in the E&P Drilling segment. Insignificant results could be a result of the low number of observations.

Within the Decommissioning segment, companies with higher revenue growth, on average, invested less in R&D. One economic interpretation could be that companies struggle to deliver growth invest more in R&D in order to increase their growth rates.

In Seismic, the one-year lagged profit margin was statistically significant at 10% level. The results indicate that profit margin is directly related to subsequent net R&D investment, similar to the Operations segment.

What affects the decision to invest in R&D differ across segments. Economically speaking, the effects seem apparent. In light of the regression results and the economic interpretation, we conclude that profitability seems to play an essential role for the level of R&D investments in Norwegian OFS companies. Similar results were found when control variables were excluded (see Appendix 3). We are, therefore, not able to draw causal conclusions based on the results in Model 1. It makes economic sense that profitability matters for the decision to invest in R&D, and past literature and our results suggest that there are some effects of R&D on financial performance. Consequently, the variables may be bi-directionally related.

Not only prior financial performance had an impact on R&D investments. For all segments, the results revealed size to be inversely related to subsequent net R&D. The result is in line with the findings of Xu and Sim (2018), who found that size restricts the R&D intensity. Smaller companies may be more dependent on new products and services than larger.

In addition to the company-specific characteristics, macro-economic factors play a role. For all segments, higher oil price typically leads to more investments in R&D. However, the results are rather intuitive, as the oil price is a critical determinant for the activity and investment level on the Norwegian continental shelf. As mentioned in section 3, upstream oil and gas companies may be willing to finance R&D activities in the OFS companies. Such support seems more likely in times with high than low oil prices.

Table 8: Regression output for Model 2.

	Dependent variable: $\Delta R\&D_t$													
	Independent variable (X_i):													
	EBIT%$_{t-1}$	EBIT%$_{t-1}$	EBITDA%$_{t-1}$	EBITDA%$_{t-1}$	PROFIT%$_{t-1}$	PROFIT%$_{t-1}$	ROA$_{t-1}$	ROA$_{t-1}$	ROE$_{t-1}$	ROE$_{t-1}$	ATO$_{t-1}$	ATO$_{t-1}$	GROWTH$_{t-1}$	GROWTH$_{t-1}$
X_i	0.006		0.005		0.010		0.382		-0.097		1.323		-0.002	
	(0.005)		(0.003)		(0.009)		(0.369)		(0.096)		(1.571)		(0.001)	
SEG1*X_i		0.003*		0.002***		0.004		0.640		0.006		0.001		-1.127
		(0.001)		(0.001)		(0.003)		(0.541)		(0.019)		(0.001)		(0.721)
SEG2*X_i		0.236		0.363		0.267		-13.54		-0.910		-0.002		13.54
		(0.161)		(0.237)		(0.201)		(13.14)		(0.872)		(0.002)		(11.89)
SEG3*X_i		-0.095*		0.059		0.071*		-1.498		0.012		-0.003***		-0.906
		(0.048)		(0.325)		(0.040)		(1.319)		(0.039)		(0.000)		(0.693)
SEG4*X_i		0.067		0.069		0.066*		0.213		0.117		0.020		2.843
		(0.042)		(0.065)		(0.040)		(3.365)		(0.226)		(0.026)		(5.703)
SEG5*X_i		0.452		0.513		0.370		2.684		0.213		-0.052		-2.852**
		(0.332)		(0.350)		(0.291)		(2.214)		(0.180)		(0.243)		(1.158)
OIL$_{t-1}$	0.030**	0.030**	0.030**	0.030**	0.030**	0.031**	0.023**	0.028*	0.024**	0.025**	0.024**	0.024**	0.027**	0.023**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.012)	(0.016)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)	(0.010)
CASH$_{t-1}$	6.092	6.216	6.082	6.344	6.095	6.277	6.813	7.446	6.931	7.085	6.942	6.940	6.286	6.892
	(4.978)	(5.031)	(4.977)	(5.066)	(4.979)	(5.033)	(6.901)	(7.370)	(6.949)	(7.049)	(6.972)	(6.994)	(5.153)	(5.402)
EMP$_{t-1}$	256.6	250.3	253.9	247.4	261.8	254.3	387.7	405.7	347.1	349.0	349.3	349.1	220.2	265.2
	(268.2)	(266.7)	(268.0)	(266.7)	(269.8)	(268.5)	(327.3)	(346.9)	(286.9)	(286.8)	(288.8)	(288.7)	(229.4)	(261.9)
SIZE$_{t-1}$	-4.629***	-4.674***	-4.632***	-4.686***	-4.622***	-4.633***	-5.364*	-5.216*	-5.407*	-5.426*	-5.410*	-5.415*	-4.300***	-4.001***
	(1.742)	(1.748)	(1.743)	(1.753)	(1.738)	(1.734)	(2.852)	(2.739)	(2.877)	(2.879)	(2.876)	(2.884)	(1.512)	(1.329)
DEBT$_{t-1}$	0.095	0.084	0.090	0.083	0.104	0.095	0.333	0.447	0.169	0.168	0.170	0.169	0.063	0.158
	(0.329)	(0.328)	(0.328)	(0.329)	(0.334)	(0.333)	(0.455)	(0.548)	(0.335)	(0.334)	(0.337)	(0.336)	(0.298)	(0.355)
GOODWILL$_{t-1}$	21.45	21.45	21.44	21.41	21.45	21.69	24.24	24.25	23.81	21.86	24.04	24.04	21.91	20.19
	(14.71)	(14.70)	(14.71)	(14.72)	(14.71)	(14.70)	(19.39)	(19.32)	(19.69)	(19.09)	(19.41)	(19.42)	(15.11)	(14.90)
Constant	49.41***	49.97***	49.44***	50.11***	49.33***	49.47***	57.87*	55.57**	58.46*	58.63*	58.52*	58.57*	43.97***	41.00***
	(17.80)	(17.89)	(17.81)	(17.95)	(17.76)	(17.75)	(29.84)	(28.15)	(30.19)	(30.19)	(30.18)	(30.27)	(14.74)	(13.53)
Observations	5,995	5,995	5,995	5,995	5,995	5,995	5,352	5,352	5,347	5,347	5,353	5,353	5,995	5,995
R-squared	0.019	0.021	0.019	0.022	0.019	0.022	0.022	0.032	0.022	0.027	0.022	0.022	0.020	0.038
Number of id	616	616	616	616	616	616	608	608	608	608	609	609	616	616

Note: Robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1. R&D is the sum of capitalised R&D and patent rights divided by total assets. EBIT% and EBITDA% are the EBIT- and EBITDA margin. PROFIT% is net earnings/total revenues. ROA is the return on assets, and ROE is the return on equity. ATO is total revenue/total assets. GROWTH is the growth in total revenues. CASH is cash and equivalents divided by total assets. EMP is the number of employees divided by total assets. SIZE it the logarithmic value of total assets. DEBT is total debt to total assets. GOODWILL is goodwill to total assets. OIL = Europe Brent Spot Price FOB.

7. Conclusion

Understanding the effect of innovation is crucial as it is both capital intensive and risky. By analysing a comprehensive dataset consisting of 14 years of accounting data for Norwegian oilfield service companies, this paper adds new insights to the impact of R&D investments on financial performance.

In contrast to the supportive consensus among other researchers, we did not find sufficient evidence for R&D investments to have a positive impact on financial performance. However, the results indicate that R&D investments cause asset turnover to decrease. There are some other segment-specific effects, but our analysis suggests that these are a result of bidirectional relationships and randomness rather than causal effects. We found more persuasive evidence for a direct relationship between financial performance and subsequent R&D investments, but not enough to draw general conclusions. With the results of this analysis, the authors of this paper find it strange that a large extent of literature is unambiguously supportive to investments in R&D.

In general, investments in R&D do not seem to be a silver bullet for long term profitability for oil service companies and is probably not the reason why some Norwegian OFS companies have outperformed others. Managers should carefully analyse each R&D project separately, and investors cannot rely on R&D activities as a sign of future financial performance.

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Appendix

Appendix 1: Segment description

The following segment descriptions are mainly retrieved from EY's Norwegian oilfield services analysis 2019.

Segment 1 - Engineering, fabrication & installation

Companies in this segment are involved in equipment supply, construction, manufacturing, and installation of offshore production units, both topside and subsea. The segment consists of five sub-segments (EY, 2020, pp. 15-18):

- *Consultants and engineering houses* provide skilled personnel and consultants to other OFS companies and E&P companies.
- *Shipyards* construct vessels such as Platform Supply Vessels (PSV), Anchor Handling Tug Supply (AHTS) vessels, and Offshore Subsea Construction (OSCV) vessels.
- *Subsea* includes those who engineer and fabricate subsea equipment. It also includes companies working with risers and flowlines, subsea umbilicals, and inspection, maintenance, and repair.
- *Workshops & product suppliers* design, develop, fabricate, and sell products and systems. This is typically offered to vessels and offshore installations.
- *Yards/Larger EPCI* offer engineering, procurement, construction, and installation of modules and facilities used in production and processing. Companies in this segment are usually also crucial maintenance and modification contractors for topside facilities and onshore terminals.

Segment 2 - Exploration & production drilling

Exploration and production drilling consist of companies that own or operate drilling rigs, and companies that provide systems, services, and products to drilling rigs and oil wells. The segment consists of three sub-segments (EY, 2020, pp. 11-13):

- *Rig companies* owns or operates offshore drilling rigs.
- *Rig equipment* companies offer equipment and systems for both rigs and topsides.

- *Well service* companies offer integrated project management, products and services related to drilling and well construction. These companies also offer intervention and other operations during the wells' life cycle.

Segment 3 - Operations

This segment includes companies that support upstream oil companies. The segment consists of three sub-segments (EY, 2020, pp. 20-21):

- *Maintenance & Modification* companies offer inspection services, passive fire protection and surface treatment for offshore installations.
- *Offshore logistics* companies own and operate helicopters, supply bases and offshore vessels.
- *Production* companies offer services and equipment in the production phase. Floating production and storage offloading (FPSO) units, waste management, facility management, and communication are examples of such services.

Segment 4 – Reservoir and seismic

Companies in this segment

- operate seismic vessels to gather data,
- analyse, consult, interpret, and display seismic data, or
- manufacture and supply equipment for these activities (EY, 2020, p. 9).

Segment 5 - Decommissioning

Companies in this segment primarily work with the decommissioning of offshore installations. Many OFS companies offer decommissioning-related services but have their primary operations in other segments (EY, 2020, p. 23).

Appendix 2: Model 1 without control variables

Table A-1: Regression output for Model 1 without control variables.

VARIABLES	(1) $EBIT\%_t$	(2) $EBIT\%_t$	(3) $EBITDA\%_t$	(4) $EBITDA\%_t$	(5) $PROFIT\%_t$	(6) $PROFIT\%_t$	(7) ROA_t	(8) ROA_t	(9) $RO.E_t$	(10) $RO.E_t$	(11) ATO_t	(12) ATO_t	(13) $GROWTH_t$	(14) $GROWTH_t$
$R\&D_{t-1}$	0.083		0.087		0.054		-0.002*		0.005		-0.006***		-0.038	
	(0.141)		(0.116)		(0.140)		(0.001)		(0.007)		(0.002)		(0.071)	
SEG1 * $R\&D_{t-1}$		0.487		0.416		0.374		-0.005***		0.024		-0.011***		-0.127
		(0.461)		(0.387)		(0.361)		(0.001)		(0.015)		(0.002)		(0.090)
SEG2 * $R\&D_{t-1}$		-0.258*		-0.142		-0.391*		0.000		0.009		-0.007***		-0.082
		(0.154)		(0.114)		(0.233)		(0.003)		(0.013)		(0.002)		(0.074)
SEG3 * $R\&D_{t-1}$		0.131		0.065		0.319		-0.002		-0.005		-0.003		0.213
		(0.111)		(0.046)		(0.273)		(0.002)		(0.007)		(0.003)		(0.229)
SEG4 * $R\&D_{t-1}$		-0.026		-0.009		-0.027		-0.003**		-0.016		0.001		-0.142
		(0.012)		(0.012)		(0.021)		(0.001)		(0.014)		(0.004)		(0.140)
SEG5 * $R\&D_{t-1}$		4.790		4.593		11.16***		-0.025***		-0.178		0.019		-1.100
		(6.285)		(5.305)		(1.902)		(0.009)		(0.252)		(0.046)		(1.056)
Constant	-2.161***	-2.290***	-1.865***	-1.985***	-1.744**	-1.852**	0.038***	0.038***	0.225***	0.217***	1.554***	1.557***	4.842***	4.909***
	(0.684)	(0.782)	(0.561)	(0.646)	(0.677)	(0.719)	(0.006)	(0.006)	(0.034)	(0.034)	(0.007)	(0.007)	(0.351)	(0.311)
Observations	5,996	5,996	5,996	5,996	5,996	5,996	5,996	5,996	5,991	5,991	5,994	5,994	5,354	5,354
R-squared	0.000	0.003	0.000	0.002	0.000	0.005	0.000	0.000	0.000	0.000	0.003	0.005	0.000	0.000
Number of id	616	616	616	616	616	616	616	616	616	616	615	615	609	609

Source: (U.S. Energy Information Administration, 2020) and (EY, 2020).

Note: Similar to Model 1a, but without control variables. Robust standard errors in parentheses. Significance level *** $p<0.01$, ** $p<0.05$, * $p<0.1$. R&D is the sum of capitalised R&D and patent rights divided by total assets. EBIT%, EBITDA% and PROFIT% are the EBIT-, EBITDA- and profit margin. ROA is the return on assets, and ROE is the return on equity. ATO is total revenue/total assets. GROWTH is the growth in total revenues. CASH is cash and equivalents divided by total assets. EMP is the number of employees divided by total assets. SIZE it the logarithmic value of total assets. DEBT is total debt to total assets. GOODWILL is goodwill to total assets. OIL = Europe Brent Spot Price FOB.

Appendix 3: Model 2 without control variables

Table A-2: Regression output for Model 2 without control variables.

	Dependent variable: $\Delta R\&D_t$													
	Independent variable (X_i):													
	$EBIT\%_{t-1}$	$EBIT\%_{t-1}$	$EBITDA\%_{t-1}$	$EBITDA\%_{t-1}$	$PROFIT\%_{t-1}$	$PROFIT\%_{t-1}$	ROA_{t-1}	ROA_{t-1}	$RO.E_{t-1}$	$RO.E_{t-1}$	ATO_{t-1}	ATO_{t-1}	$GROWTH_{t-1}$	$GROWTH_{t-1}$
X_i	0.006*		0.006**		0.009		-0.104		-0.101		2.709		-0.001**	
	(0.003)		(0.003)		(0.006)		(0.181)		(0.102)		(2.029)		(0.001)	
SEG1*X_i		0.003***		0.004***		0.003***		0.055		0.010		0.361		0.000
		(0.001)		(0.000)		(0.001)		(0.078)		(0.015)		(0.408)		(0.000)
SEG2*X_i		0.225		0.344		0.267		-13.74		-0.903		15.16		-0.001
		(0.155)		(0.226)		(0.204)		(13.42)		(0.879)		(12.32)		(0.001)
SEG3*X_i		-0.101*		-0.058		0.064**		-1.086		-0.022		0.149		-0.002***
		(0.057)		(0.359)		(0.028)		(1.247)		(0.022)		(0.278)		(0.000)
SEG4*X_i		0.028		-0.002		0.026		-1.115		0.041		3.711		0.054***
		(0.055)		(0.100)		(0.047)		(4.329)		(0.293)		(6.137)		(0.018)
SEG5*X_i		0.046**		0.048*		0.043**		-0.127		-0.0110		-0.429		0.046*
		(0.023)		(0.027)		(0.021)		(0.206)		(0.010)		(0.639)		(0.028)
Constant	2.216***	2.263***	2.215***	2.281***	2.217***	2.281***	1.827***	1.793***	1.846***	1.881***	1.829***	1.822***	-1.960	-1.779
	(0.004)	(0.040)	(0.003)	(0.050)	(0.006)	(0.046)	(0.006)	(0.043)	(0.028)	(0.060)	(0.003)	(0.002)	(3.121)	(2.927)
Observations	5,996	5,996	5,996	5,996	5,996	5,996	5,353	5,353	5,348	5,348	5,354	5,354	5,996	5,996
R-squared	0.000	0.002	0.000	0.003	0.000	0.003	0.000	0.009	0.001	0.005	0.000	0.000	0.005	0.023
Number of id	616	616	616	616	616	616	608	608	608	608	609	609	616	616

Source: (U.S. Energy Information Administration, 2020) and (EY, 2020).

Note: Similar to Model 1a, but without control variables. Robust standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1. R&D is the sum of capitalised R&D and patent rights divided by total assets. EBIT%, EBITDA% and PROFIT% are the EBIT-, EBITDA- and profit margin. ROA is the return on assets, and ROE is return on equity. ATO is total revenue/total assets. GROWTH is the growth in total revenues. CASH is cash and equivalents divided by total assets. EMP is the number of employees divided by total assets. SIZE it the logarithmic value of total assets. DEBT is total debt to total assets. GOODWILL is goodwill to total assets. OIL = Europe Brent Spot Price FOB.