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Large Oil Spills and Capital Investments

The shock of the Deepwater Horizon oil spill

ABSTRACT

This paper examines the effect of the shock of the Deepwater Horizon oil spill on the offshore oil drilling firms in the U.S. Gulf of Mexico and their capital investments by examining four dimensions of capital investments: disposition of assets, capital expenditure, fleet size, and fleet riskiness. This study finds that the effect of the shock of the Deepwater Horizon oil spill, on average, was slightly positive but close to zero. In addition, it provides evidence that the offshore oil drilling firms, on average, increased their capital investments in the aftermath of the Deepwater Horizon oil spill.

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PREFACE AND ACKNOWLEDGEMENTS

I proudly present to you my master thesis: Large Oil Spills and Capital Investments – The shock of the Deepwater Horizon oil spill.

I would like to utilize this opportunity to pay my gratitude to the Erasmus University Rotterdam and particularly the Erasmus School of Economics for enabling me to accomplish my education in Economics and Business Economics after five dynamic and amazing years. Beside all the know-how I gained during my time at the Erasmus University Rotterdam, it developed me into the person I am today, and especially evolved my mind-set.

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1. INTRODUCTION

April 20th, 2010, news around the world was heavily dominated by the event of the Deepwater Horizon oil spill. On this day, the Deepwater Horizon, an oil drilling rig licensed by Transocean Ltd to British Petroleum (BP), exploded during drilling exploration in the U.S. Gulf of Mexico (hereafter US GOM). The Deepwater Horizon oil spill killed 11 people who were working on the rig and an estimated 680.000 tons of oil were spilled (Eckle, Burgherr & Michaux, 2012). The Deepwater Horizon oil spill is known as the worst environmental disaster in U.S. history and had major economic effects, such as for the commercial fishing and oil drilling industry.

This study focuses on the economic effects of the oil spill, by examining the effect of the Deepwater Horizon oil spill on the offshore oil drilling firms that are active in the US GOM. Specifically, this study examines the effect of the Deepwater Horizon oil spill on the capital investments of these firms. Therefore, the research question of this study is: has the shock of the Deepwater Horizon oil spill suppressed the capital investments of the offshore oil drilling firms? One would expect the latter would occur due to uncertainty, economic instability, and losses made in the aftermath of the oil spill. This study examines this relationship by analyzing four dimensions of capital investments: (1) disposition of assets, (2) capital expenditure, (3) fleet size, and (4) fleet riskiness. This evolves into four hypotheses to examine: (1) the Deepwater Horizon oil spill has a significant positive effect on the disposition of assets of the firms, (2) the Deepwater Horizon oil spill has a significant negative effect on the capital expenditure of the firms, (3) the Deepwater Horizon oil spill has a significant negative effect on the fleet size of the firms, and (4) the Deepwater Horizon oil spill has a significant negative effect on the fleet's riskiness of the firms.

Ever since the Deepwater Horizon oil spill occurred, there has been an ongoing debate regarding the consequences and effects the oil spill had. However, the clear majority of these debates regard the environmental effects of the Deepwater Horizon oil spill. Prior research especially focuses on environmental issues, such as the pollution of the deep-water coral community (White, et al., 2012), whereas research on economic effects remains limited to the fishing industry (McCrea-Strub, et al., 2011) and the effects on national level (Smith, Smith & Ashcroft, 2011). Therefore, there exists an important gap in the literature regarding the effects on the oil drilling industry, who perform these oil drilling activities in the US GOM. This oil spill had major implications for the oil drilling industry in the US GOM. For instance, the Obama administration imposed a prohibition on deepwater offshore oil drilling in the US GOM for a period of six months after the event. The oil drilling industry experienced a huge setback due to the Deepwater Horizon oil spill. It will be insightful to analyze how it affected the capital investments of these firms, since there is little to no evidence on this matter. Thereby, this research contributes a yet researched relationship to the existing literature.

This thesis is divided in two main parts. On one hand, the event study regarding the effect of the shock of Deepwater Horizon oil spill on the offshore oil drilling firms and on the other hand the difference-in-difference study regarding the effect on the capital investments of these firms. This paper uses daily stock returns which are retrieved through Compustat via WRDS. The event study method has an estimation period and an event period. The estimation period for this study is defined as day -244 till day -6, whereas the event period regards the period from day -5 till +5. Day 0 is defined as the day that the event occurred. Consequently, this study uses a maximum of 250 daily return observations. Moreover, this study uses a panel data set of ten offshore oil drilling firms that operated in the US GOM from 2005 till 2015. The key financial metrics, disposition of assets, capital expenditure and fleet size, are retrieved from the annual reports of the firms via the database of the U.S. Securities and Exchange Commission (SEC). In addition, additional important data such as the control variables, are retrieved from Compustat via Wharton Research Data Services (WRDS). This study uses a difference-in-differences method. Thereby, this study examines the effects of pre-treatment and post-treatment outcomes for a treatment and a control group, where the treatment group is exposed to the treatment and the control group remains untreated.

This study finds that the effect of the shock of the Deepwater Horizon oil spill, on average, was slightly positive but close to zero, regarding the cumulative abnormal returns of the offshore oil drilling firms. In addition, this paper provides evidence that the oil drilling industry shows a significant reaction regarding their investment pattern after the Deepwater Horizon oil spill. The treatment group, which has a higher exposure to the shock of the Deepwater Horizon oil spill, significantly reduced their disposition of assets relatively to the control group, whereas one would expect them to increase their disposition of assets to strengthen their capital stock. Moreover, the treatment group significantly increased their capital expenditure, relatively to the control group. This is not in line with the expectations since one would expect them to reduce their capital expenditure due to uncertainty and economic instability. These two dimensions of capital investments show that these firms reacted contradictory to what is expected. On the other hand, the results show that the offshore oil drilling firms with the higher exposure to the shock reduced their fleet size after the oil spill, which is in line with what is expected. However, this is not significant. Even though the offshore oil drilling firms reduced their fleet size, it is noteworthy to mention that, on average, they did increase their capital investments when considering the disposition of assets and capital expenditure of the firms. Therefore, one can say that the Deepwater Horizon oil spill has not suppressed the capital investments of these firms. On the contrary, it seems that it stimulated the capital investments of these firms. A possible explanation could be the acquisition of better and safer machinery and equipment. The oil drilling industry has been heavily attacked by outsiders regarding their methods and flaws regarding offshore oil drilling. To make sure that these kinds of events are prevented in the future, the oil drilling industry has been stimulated to revise their methods and machinery. An additional reason is the fact that after the oil spill, the structure of the oil drilling industry changed due to mergers and acquisitions of certain firms. For instance, Ensco Plc acquired Pride International in 2011 following the Deepwater Horizon oil spill. Furthermore, the fact that in times of financial distress prices of assets tend to be below the book value could be an explanation for the reluctance to dispose assets.

Chapter two provides a detailed insight of the theoretical background regarding the history of the oil spills and the economic impacts. Moreover, chapter three and four elaborate on the hypotheses and the research design of this study. Chapter five discusses the empirical results and analyses. Finally, chapter six concludes the study with recommendations for further research.

2. THEORETICAL BACKGROUND

This chapter elaborates on a range of the most relevant concepts and related literature regarding the economic effects of oil spills and natural disasters. This theoretical background is necessary before examining the shock of the Deepwater Horizon oil spill. Subsequently, the hypotheses can be formulated, and the research framework can be constructed.

2.1 History repeats itself

The Deepwater Horizon oil spill has not been the first oil spill and, unfortunately, will probably not be the last one mankind will experience. Numerous oil spills have taken place in the past 40 years with the Deepwater Horizon as the most recent one.

Table I: List of biggest oil spills from tankers in history

This table provides a list of the 20 biggest oil spills since 1967 from tankers that occurred in history based on spill size in tons, Deepwater Horizon and Exxon Valdez excluded. The data is retrieved from Oil Tanker Spill Statistics (2017). The columns provide incident name, location, year, and spill size (in tonnes). *Exxon Valdez positions on 35 in the rank of the biggest oil spills but is included because of its resemblance with the Deepwater Horizon oil spill.

Incident name	Location	Year	Spill size (tons)
DEEPWATER HORIZON	**U.S. Gulf of Mexico**	**2010**	**780.000**
ATLANTIC EMPRESS	Off Tobago, West Indies	1979	287.000

ABT SUMMER	700 nautical miles off Angola	1991	260.000
CASTILLO DE BELLVER	Off Saldanha Bay, South Africa	1983	252.000
AMOCO CADIZ	Off Brittany, France	1978	223.000
HAVEN	Genoa, Italy	1991	144.000
ODYSSEY	700 nautical miles off Nova Scotia, Canada	1988	132.000
TORREY CANYON	Scilly Isles, UK	1967	119.000
SEA STAR	Gulf of Oman	1972	115.000
IRENES SERENADE	Navarino Bay, Greece	1980	100.000
URQUIOLA	La Coruna, Spain	1976	100.000
HAWAIIAN PATRIOT	300 nautical miles off Honolulu	1977	95.000
INDEPENDENTA	Bosporus, Turkey	1979	94.000
JAKOB MAERSK	Oporto, Portugal	1975	88.000
BRAER	Shetland Islands, UK	1993	85.000
AEGAN SEA	La Coruna, Spain	1992	74.000
SEA EMPRESS	Milford Haven, UK	1996	72.000
KHARK 5	120 nautical miles off Atlantic coast of Morocco	1989	70.000
NOVA	Off Khari Island, Gulf of Iran	1985	70.000
KATINA P	Off Maputo, Mozambique	1992	67.000
PRESTIGE	Off Galicia, Spain	2002	63.000
*EXXON VALDEZ**	*Prince William Sound, Alaska, USA*	*1989*	*37.000*

Table I provides an overview of the 20 biggest oil spills from tankers in history based on the spill size which is denoted in tons, Deepwater Horizon and Exxon Valdez excluded (ITOPF, 2017). The table shows that the Atlantic Empress was ranked as the largest oil spill based on spill size in tons in history before the Deepwater Horizon oil spill occurred. Noteworthy is the fact that just one of these events, Prestige, occurred after 2000. This means that the Deepwater Horizon oil spill is one of the few major oil spill events that occurred after 2000 together with the Prestige oil spill. Therefore, it is interesting to examine the effects this event had in this modern era, with all the new technology. The Exxon Valdez oil spill is relatively a much smaller oil spill regarding the other spills listed in table I, with position 35 in the rank of large oil spills. However, it is included because of its resemblance with the Deepwater Horizon oil spill.

2.2 Comparison of Deepwater Horizon and Exxon Valdez oil spill

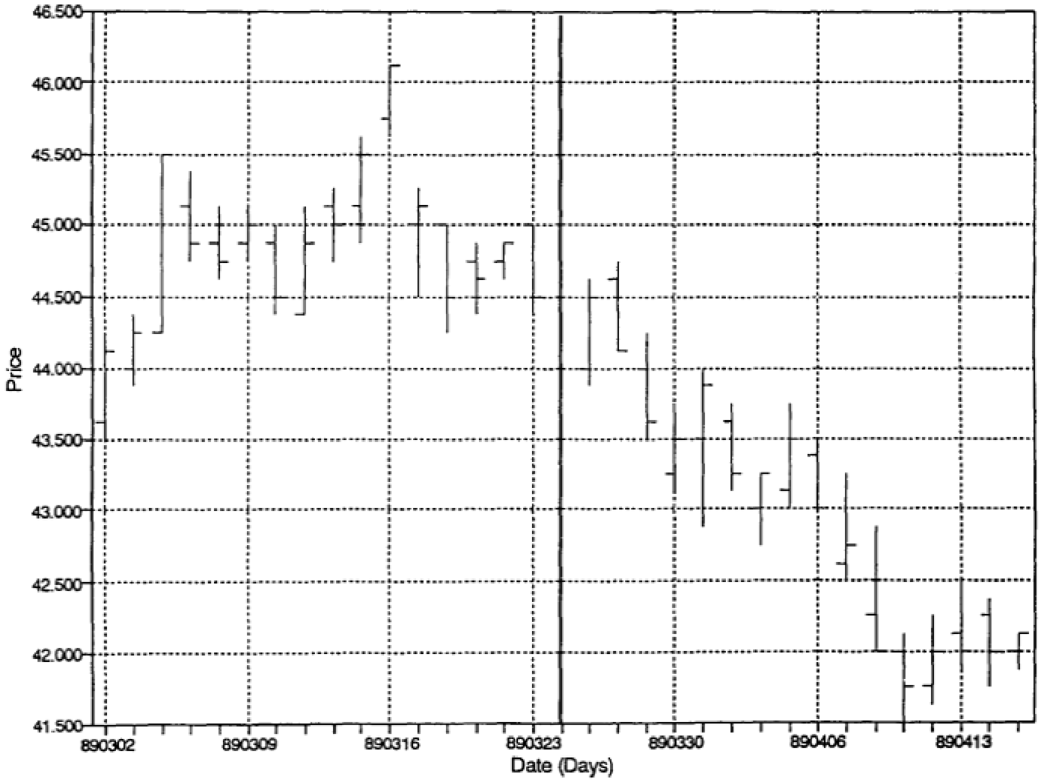
Even though the Exxon Valdez oil spill (March 24, 1989) is not the biggest oil spill based on spill size in tons, it is labeled as one of the largest oil spills regarding ecological damaging oil release in North-America together with the Deepwater Horizon oil spill (Gill, Picou & Ritchie, 2012). Therefore, considering the Exxon Valdez oil spill and its economic effects could provide valuable insights.

Mark White (1996) examined the effect of the Exxon Valdez oil spill on the investment returns to shareholders and the oil industry. News diffused quickly after the oil spill occurred, and investors acted upon this tragedy by estimating the impact of the clean-up costs, future liabilities and legal fees, discontinuation of supply, and consumer boycotts.

This study documents strong negative and idiosyncratic effects on the Exxon corporation, which was held responsible for the oil spill. Exxon's shareholders showed a sustained and significant negative reaction shortly after the oil spill. Exxon's co-owners and retail competitors displayed the same response after the oil spill.

These results are in line with previous research. This effect was heavily enforced due to uncertainty about future liabilities, future oil prices and the impact of a possible stricter safety regulation. In addition, the research provides evidence that the losses were bigger for high-exposure firms than for low-exposure firms. One would expect the stock market to react immediately after the oil spill.

Figure I: Share price of Exxon Valdez before and after the oil spill[1]



[1] Source: Herbst, A. F., Marshall, J. F., & Wingender, J. (1996). An Analysis of the Stock Market's Response to the Exxon Valdez Disaster. *Global Finance Journal*, 101-114.

Figure I shows that Exxon's share price fell sharply after the oil spill, but only shows a small decline a week later and the share prices started to rise again after two more weeks. Other firms in the industry, such as British Petroleum, exhibit the same pattern as Exxon. In addition, there is no significant change in the volatility of share prices for firms active in the oil industry after the oil spill (Herbst, Marshall & Wingender, 1996). These results imply that the market was able to assess that the present value of the total damages would eventually be insignificant.

2.3 Economic effects of natural disasters

The Deepwater Horizon is an oil rig constructed by Transocean Limited and was licensed to British Petroleum (BP). The construction cost of this oil rig amounted to 365 million US dollars (Smith, Smith & Ashcroft, 2011). The authors document that the total damages amounted to 36.9 billion US dollars when considering BP, and the direct environmental and economic damages to US GOM area. According to their study, the damages because of the oil spill can be accounted to three main causes. First, human errors and the failure of the equipment of the Deepwater Horizon offshore drilling unit. Second, the drawdown of the US government to allocate resources to aid with containing the oil spill. Third, the misinformation dispersed by the media regarding the oil spill size and the location of pollution.

To obtain a better know-how of the financial impact of natural disasters, it is important to analyze earlier research. Benson and Clay (2004) document that natural disasters can lead to negative economic effects in the short-run as well as in the long-run, such as for the growth of the economy and poverty reduction. Moreover, it can have a significant impact on a firm's appetite for public finance due to increasing expenditures. More specifically, the negative effects of an oil spill are often a cutback in offshore oil drilling activity in that area, a blow to commercial fishing due to the polluted water, and the negative impact on tourism (Smith, Smith & Ashcroft, 2011). The US government introduced a prohibition of six months on deepwater offshore oil drilling after the Deepwater Horizon oil spill. This had a major impact on the offshore oil drilling firms that operated mainly in the US GOM. When considering the short-term impacts of natural disasters, it can be shown that these natural disasters tend to have a negative impact on a country's gross domestic product (hereafter GDP) in the short-run (Charveriat, 2000). Charveriat (2000) found that numerous disasters in Latin America and the Caribbean in the period from 1980 till 1996 led to a sharp decline in the real growth rates in the same year as the disaster took place but document a sharp rise in the two years post-event. This would imply that the negative effects of a natural disaster only hold in the short-run, which is contrary to Benson and Clay's (2004) findings. On the other hand, Albala-Bertrand (1993) and

Doughty (1971) provide evidence that, on average, a country's GDP tend to increase post a natural disaster.

Taking a deeper dive into the long-term impacts of natural disasters shows that capital assets and labor growth and productivity can experience huge blows due to natural disasters. All major types of disasters could possibly disrupt investments plans in the long-run due to economic instability and uncertainty (Skidmore & Toya, 2002). In addition, disaster risks can have different effects for different countries. Skidmore and Toya (2002) conclude that a natural disaster could give a firm the opportunity to strengthen its capital stock. On the other hand, higher disaster risk can lead to a negative decrease in physical capital investment. However, there is still little evidence to support this.

3. HYPOTHESIS DEVELOPMENT

This chapter follows up on the theoretical background discussed in chapter two of this study. This chapter explains the formulation of the hypotheses based on the findings regarding the previous literature and its most relevant concepts.

3.1 Hypothesis 1: The Deepwater Horizon oil spill has a significant positive effect on the disposition of assets of the firms

Skidmore and Toya (2002) document that all major type of disasters could have severe effects on firms regarding the disruption of investments plans due to uncertainty risk. In addition, they state that a disaster, such as an oil spill, gives the firm the opportunity to strengthen their capital stock. These two results would imply that firms are hesitant to make investments and rather endeavor to add capital to their capital stock after an oil spill. One major resource of strengthening the capital stock is the disposition of assets. Therefore, one would expect the disposition of assets to significantly increase after the Deepwater Horizon oil spill. Consequently, the first hypothesis examines the effect of the Deepwater Horizon oil spill on the disposition of assets of the offshore oil drilling firms.

3.2 Hypothesis 2: The Deepwater Horizon oil spill has a significant negative effect on the capital expenditure of the firms

Benson and Claye (2004) show that natural disasters have negative economic short-term as well as long-term effects for the economy in the environment of the disaster. They document that such a disaster has a significant negative effect on a firm's appetite to finance investments.

Skidmore and Toya (2002) suggested that capital assets can experience a huge blow due to uncertainty and economic instability. Moreover, this high disaster risk can lead to a significant reduction in physical capital investment. Capital expenditure is a mean to acquire, improve or maintain physical assets, such as equipment. This implies that one can expect the capital expenditure of these firms to drop after the oil spill. Therefore, the second hypothesis analyzes the effect of the Deepwater Horizon oil spill on the capital expenditure of the firms.

3.3 Hypothesis 3: The Deepwater Horizon oil spill has a significant negative effect on the fleet size of the firms

Barack Obama´s administration imposed a prohibition on offshore oil drilling activity in the US GOM, shortly after the Deepwater Horizon oil spill, which lasted six months. Therefore, the offshore oil drilling firms were not able to perform their deep-water operations during that period. This led to heavy pressure on their income sources and resulted in losses. As discussed, a major income source for these firms is the disposition of assets and a major component of the firm´s assets regard their drillships (i.e. the firm's fleet size). Therefore, one expects the firms to reduce their fleet size, especially during the period of the prohibition. Consequently, the third hypothesis tests the effect of the Deepwater Horizon oil spill on the fleet size of the firms.

3.4 Hypothesis 4: The Deepwater Horizon oil spill has a significant negative effect on the fleet's riskiness of the firms

To follow up on hypothesis three, this study examines if the firms take their reduction of fleet size a step further and especially reduce the deepwater drillships of their fleet size. Since this oil spill regards deepwater drill activity, the fleet's riskiness reflects the portion of deepwater drillships of the fleet size of the firm. Therefore, the fourth hypothesis examines the effect of the Deepwater Horizon oil spill on the riskiness of the fleet size of the firms.

4. RESEARCH DESIGN

This chapter provides an insight into the data and methodology of this study. This chapter starts by discussing the sample, period and data sources. Furthermore, a list of the analyzed firms is provided. In addition, an explanation of the control variables and their definitions is given. Thereafter, this chapter elaborates on the methodology of this study. Finally, a predictive validity framework is provided.

4.1 Data Description

This thesis works with a panel data set of ten offshore oil drilling firms that operated in the US GOM from 2005 till 2015. This list is constructed out of 50 possible firms (Table XII, Appendix) that need to meet the following criteria: (1) the firm's focus is offshore oil drilling, (2) the firm should be active in the US GOM through the whole sample period, and (3) available information on capital expenditure, dispositions of assets and fleet size. This results in reducing the sample size from 50 to ten firms. Consequently, the ten offshore oil drilling firms in this study comply with all three criteria. Table II provides the list of the offshore oil drilling firms.

Table II: List of offshore oil drilling firms

This table shows the ten offshore oil drilling firms that operate in the U.S. Gulf of Mexico (US GOM) during the period 2005-2015. The sample is constructed based on the following criteria: (1) offshore oil drilling activity, (2) active in the US GOM from at least 2005 till 2015, (3) availability of information on the disposition of assets, capital expenditure and fleet size. The second and third column provides the firm's ticker and cusip code respectively.

*Extensive role in the cause of the Deepwater Horizon oil spill in April 2010.

Firm	Ticker	Cusip
Atwood Oceanics Inc	ATW	05009510
Diamond Offshore Drilling Inc	DO	25271C10
Ensco Plc	ESV	G3157S10
Helmerich & Payne Inc	HP	42709330
Hercules Offshore Inc	HERO	42345210
Nabors Industries Ltd	NBR	G6359F10
Noble Corp Plc	NE	G6543110
Parker Drilling Co	PKD	70108110
Rowan Companies Plc	RDC	G7665A10
Transocean Ltd*	RIG	H8817H10

The data regarding these firms is retrieved from the firm's annual reports via the database of the U.S. Securities and Exchange Commission (SEC) and Compustat via Wharton Research Data Services (WRDS). The annual reports provide firm information and financials from 2005 up to and including 2015. The relevant variables obtained from the annual reports are the disposition of assets, capital expenditure, and fleet size. Fleet size is categorized into three categories, namely (1) deepwater drillships, (2) midwater drillships, and (3) jack-ups. The share of deepwater drillships of the total fleet size is the measure for fleet riskiness. Compustat (WRDS) provides the control variables (or the key variables to construct the control variables) and CRSP delivers the daily stock prices of the firms to calculate the stock returns for the event study. Table III provides the descriptive statistics of the variables.

Table III: Descriptive statistics

This table presents the descriptive statistics for ten offshore oil drilling firms with data obtained from the annual reports of the firms, which are retrieved via the Securities Exchange Commission (SEC), and through Compustat (via Wharton Research Data Services) for the period 2005-2015. The year 2010 is excluded from the sample, since the Deepwater Horizon oil spill occurred April 2010. Consequently, this year is rather a border for the pre- and post-event period. *Total Assets* are denoted in million US dollars. *Fleet Size* reflects the drilling equipment of the firms which is classified into three categories: (1) deepwater drillships, (2) midwater drillships, and (3) jack-ups. *Fleet Riskiness* represents the ratio of deepwater drillships divided by the total fleet size. *Dispositions/Assets* is the ratio of the sale of assets divided by total assets. *CAPEX/Assets* reflects the ratio of the capital expenditure divided by total assets. *Book Leverage* is the ratio of the sum of long-term debt and debt in current liabilities to total assets. *Sales/Assets* represents the ratio of total sales divided by total assets. *Profitability* is measured by return on assets, which reflects the ratio of profit divided by total assets. *Dividend/Assets* is the ratio of total dividend by total assets. *General Expenses/Assets* is the ratio of general expenses to total assets.

Variable	Obs.	Mean	Std. Dev.	Min	Median	Max
Total Assets (in millions)	100	8,223	8,61	355	5,721	36,436
Fleet Size	100	37.8	31.5	6.0	30.5	137.0
Deep Water	100	12.8	12.9	0.0	9.5	50.0
Mid Water	100	4.7	8.2	0.0	0.0	29.0
Jack-ups	100	20.3	18.7	0.0	13.0	67.0
Fleet Riskiness	100	0.381	0.311	0.000	0.361	1.000
Dispositions/Assets	100	0.009	0.013	(0.001)	0.004	0.076
CAPEX/Assets	100	0.140	0.076	0.017	0.127	0.474
Book Leverage	100	0.544	0.513	0.016	0.504	3.965
Sales/Assets	100	0.407	0.137	0.142	0.416	0.718
Profitability (ROA)	100	0.197	0.070	0.062	0.197	0.464
Dividends/Assets	100	0.018	0.043	0.000	0.004	0.287
General Expenses/Assets	100	0.020	0.013	0.003	0.016	0.061

4.2 Control Variables

Five control variables are incorporated into the analysis to ensure that the regression is as less as possible affected by external factors or is subject to omitted variable bias. The control variables are book leverage, sales, profitability, dividends and general expenses. These variables are important to include since the capital investments of the firms are affected by the development of these variables.

Book Leverage

Book leverage is the ratio of long-term debt including current debt divided by total assets (Pérez-González & Yun, 2013). The variables to construct book leverage are retrieved from Compustat (WRDS, 2018).

$$Book\ Leverage = \frac{Long\text{-}term\ debt + Current\ debt}{Total\ assets} \tag{1}$$

Book leverage is important to include into the regression, since previous research has shown that leverage has a negative effect on investments (Lang, Ofek & Stulz, 1996).

Sales

Sales reflect gross sales minus cash discounts, trade discounts and returned sales (WRDS, 2018).

$$Sales = gross\ sales - (cash\ discounts + trade\ discounts + returned\ sales) \tag{2}$$

Hovakimian and Titman (2006) show that asset sales is a significant determinant of corporate investment. In addition, firms that are financially constrained display a higher sensitivity to asset sales. Therefore, sales is included into the regression as a control variable.

Profitability (ROA)

Profitability is measured by the return on assets (ROA) of a firm. Return on assets is constructed by dividing net income by total assets (WRDS, 2018).

$$Return\ on\ Assets\ (ROA) = \frac{Net\ income}{Total\ assets} \tag{3}$$

Corporate investments that are made by firms are measured by their effectiveness, which can be done by examining the return on assets. This would imply that there exists a relationship between return on assets and corporate investments.

Dividends

Dividends reflect the total amount of dividends based on the net income of the respective year (WRDS, 2018). Pogue (1969) documents a strong interdependence of corporate investment and dividend decisions. Therefore, dividends is included as a control variable.

General Expenses

General expenses are the sum of indirect operating costs incurred that are not allocated to another expense component. Consequently, it contains administrative and general expenses, equipment and occupancy expenses, and staff expenses (WRDS, 2018). These expenses could act as opportunity costs for corporate investments.

4.3 Methodology

This section provides the methodology of this study. This study aims to find the effect of the Deepwater Horizon oil spill on the offshore oil drilling firms by examining the effect on the disposition of assets, capital expenditure, fleet size and fleet riskiness. The sample is divided into two periods; pre-event and post-event. The pre-event period represents the period of 2005 till 2010 and the post-event period consists of 2011 up to and including 2015. The border between these two periods is the year 2010 since the Deepwater Horizon oil spill occurred in April 2010 and the U.S. government introduced a six-months prohibition regarding oil drilling activities in the US GOM.

4.3.1 Event study

The event study methodology evaluates the magnitude of the effect that an unexpected event, which in this paper is the shock of the Deepwater Horizon oil spill, has on the anticipated profitability and risk of a firm's portfolio, which in this study regards the stock return of the oil drilling firms. The fundamental theory that is associated with this methodology is the efficient market hypothesis (Fama et. al, 1969). This theory argues that the price of an asset should be equal to the present value of the expected future cash flows and should contain all available information. Brown and Warner (1985) document that the change in the price of an asset after the event represents the market's unbiased measure of the economic value of the event.

Thereby, two groups can be constructed based on the effect of the shock of the Deepwater Horizon oil spill on the stock returns of the firms. The two groups are divided into a treatment and a control group. The development of the stock return of the firm after the oil spill determines whether a firm is specified as a treatment or control group. Therefore, an event study is constructed to show to what extent the firm is negatively affected by the shock of the Deepwater Horizon oil spill, by examining the cumulative abnormal returns of the ten oil drilling firms around the event (+1, +3) of the Deepwater Horizon oil spill. The day of the event, day 0, is not included since the Deepwater Horizon oil spill began at nine pm. The five firms that are more negatively affected will be classified as the treatment group whereas the five firms that are less negatively affect will be classified as control group. Consequently, the effect of the shock of the Deepwater Horizon oil spill on the oil drilling firms can be observed since the outcome will be used as a measure for the treatment and control group in the analysis of the difference-in-differences method (section 4.3.2).

This paper uses daily stock returns which are retrieved through Compustat via WRDS. The event study method has an estimation period and an event period. Following the paper of Brown and Warner (1985), the estimation period for this study is defined as day -244 till day -6, whereas the event period regards the period from day -5 till +5. Day 0 is defined as the day that the event occurred. Consequently, this study uses a maximum of 250 daily return observations. The S&P Oil & Gas Exploration & Production Select Industry Index (XOP) acts as the benchmark in the event study.

This study uses the market model which is the most used model for estimating expected returns (Fama, 1970). The model is expressed as follows:

$$R_{it} = \alpha_i + \beta_i R_{Mt} + \varepsilon_{it} \tag{4}$$

Where, R_{it} reflects the return of stock *i* at time *t*, α_i represents the intercept of the linear relationship between the stock return and the returns of the market, β_i is the slope determinant measured by the sensitivity of stock *i* to the stock market, R_{Mt} displays the returns of the portfolio of all marketed assets, and ε_{it} is the unsystematic component of the returns (error term). The abnormal return, AR_{it}, is denoted by the following expression:

$$AR_{it} = R_{it} - \alpha_i - \beta_i R_{Mt} \tag{5}$$

The cumulative abnormal return, CAR_{it}, is given by the following expression:

$$CAR_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_{it} \tag{6}$$

4.3.2 Difference-in-differences method

The difference-in-differences method (DiD) examines the effects of pre-treatment and post-treatment outcomes for a treatment and a control group, where the treatment group is exposed to the treatment and the control group is untreated, for two sets of periods (Abadie, 2005). For instance, Card and Krueger (1994) examined the effect of a rise in minimum wages on employment by comparing two states, namely New Jersey and Pennsylvania. In this case, New Jersey reflects the treatment group and Pennsylvania represents the control group. The sample is divided into two periods: before and after the rise in minimum wages. The rise in the minimum wage was introduced in New Jersey and not in Pennsylvania. Therefore, Card and Krueger could identify the difference in employment that New Jersey would have experienced if the rise in the minimum wage did not take place.

The difference-in-differences method is subject to certain assumptions (Abadie, 2005). The most important assumption implies that the DiD estimator needs to follow a parallel trend over time for the average outcomes of the treatment and control group in the absence of the treatment. The model is constructed as follows:

$$Y_{i,t} = \delta_t + \alpha D_{i,t} + \eta_i + \upsilon_{i,t} \tag{7}$$

Where δ_t represents a time-specific component regarding the two periods, α reflects the effect of the treatment, η_i is an individual-specific component, and $\upsilon_{i,t}$ regards to an individual-transitory shock of which the mean is zero at each period and could be correlated in time. Therefore, $Y_{i,t}$ and $D_{i,t}$ are the observed components of the regression.

This study follows to a certain extent the same method as the paper of Abadie (2005) and Card and Krueger (1994). The biggest difference is the fact that all ten firms are subject to the shock of the Deepwater Horizon oil spill. Therefore, the treatment and control group are classified based on a different measure, which is the development of the stock price of the firm due to the shock of the Deepwater Horizon oil spill. Hereby, the heterogeneous effect of the shock can be evaluated. The difference-in-differences model of this study is defined as:

$$Y_{it} = \delta_t + \lambda_t + \alpha D_{it} + X(control\ variables)_{it} + \varepsilon_{it} \tag{8}$$

Where δ_t represents the treatment dummy that has the value one for the firms that are classified as the treatment group and the value zero for the firms that are classified as control group and is the estimated mean difference in the dependent variable between the treatment and control group before the Deepwater Horizon oil spill occurred. λ_t reflects the time-specific dummy that has the value one for the period after the Deepwater Horizon oil spill (2011-2015) and the value zero for the period before the Deepwater Horizon oil spill (2005-2009) and is the effect of the passage of time in the absence of the Deepwater Horizon oil spill. α reflects the effect of the treatment, X_i represents a set of control variables, and $\varepsilon_{i,t}$ is the error term. Consequently, $Y_{i,t}$ and $D_{i,t}$ are the observed components of the regression, where $Y_{i,t}$ is the dependent variable and

$D_{i,t}$ is the difference-in-differences estimator which provides evidence if there is a difference in the estimated mean in the dependent variable after the Deepwater Horizon oil spill for the two groups.

4.3.3 H1: The Deepwater Horizon oil spill has a significant positive effect on the disposition of assets of the firms

The first hypothesis examines the effect of the Deepwater Horizon oil spill on the disposition of assets of the firms. Therefore, the regression is as follows:

$$DoA_{i,t} = \delta_t + \lambda_t + \alpha D_{it} + X(control\ variables)_{it} + \varepsilon_{i,t} \tag{9}$$

Where the control variables consist of book leverage, sales, profitability, dividends, and general expenses, which holds for all regressions.

4.3.4 H2: The Deepwater Horizon oil spill has a significant negative effect on the capital expenditure of the firms

The second hypothesis analyzes the effect of the Deepwater Horizon oil spill on the capital expenditure of the firms. Therefore, the regression is as follows:

$$CapEx_{i,t} = \delta_t + \lambda_t + \alpha D_{it} + X(control\ variables)_{it} + \varepsilon_{i,t} \tag{10}$$

4.3.5 H3: The Deepwater Horizon oil spill has a significant negative effect on the fleet size of the firms

The third hypothesis tests the effect of the Deepwater Horizon oil spill on the fleet size of the firms. Therefore, the regression is as follows:

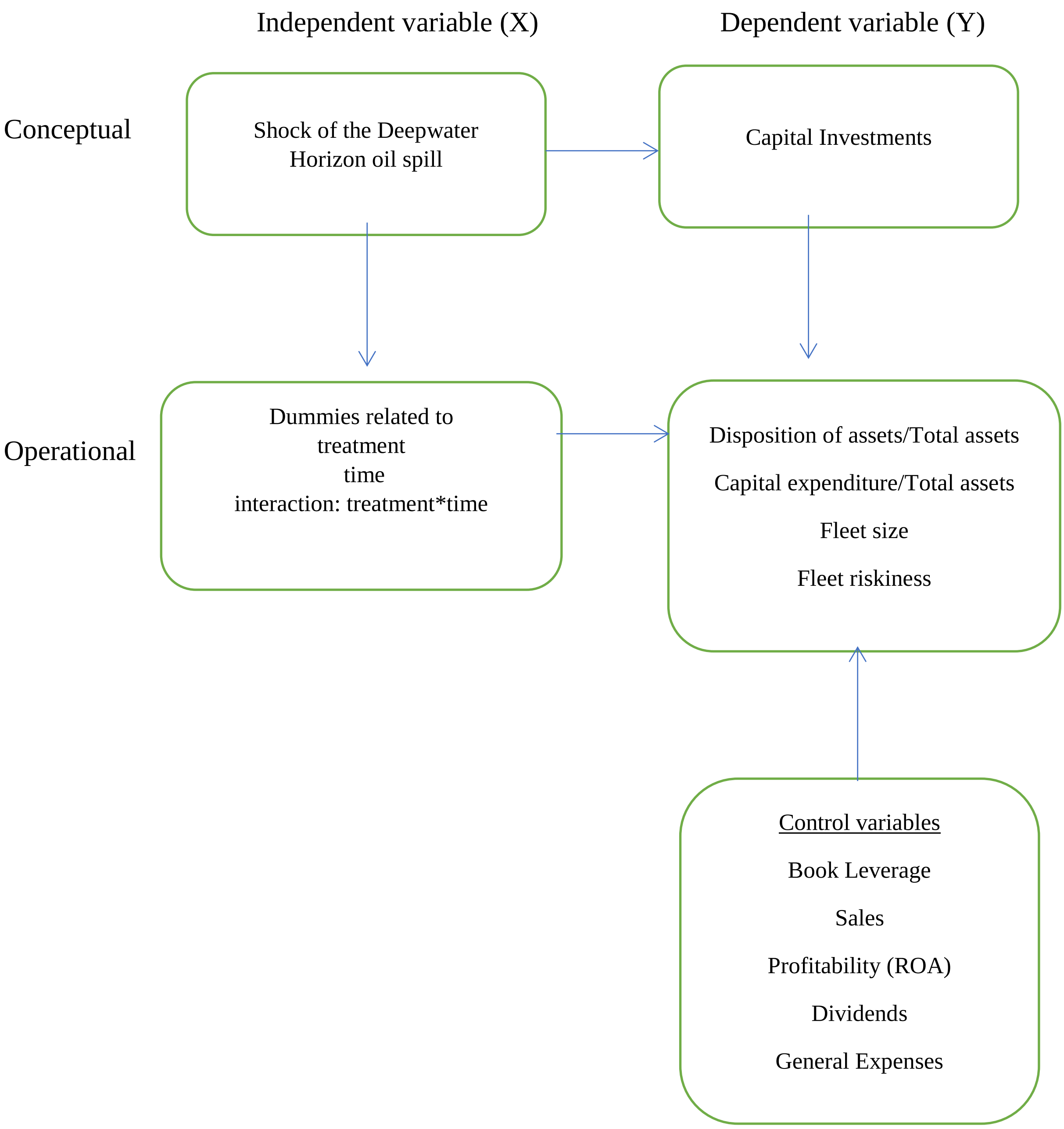
$$Fleet\ Size_{\,i,t} = \delta_t + \lambda_t + \alpha D_{it} + X(control\ variables)_{it} + \varepsilon_{i,t} \tag{11}$$

4.3.6 *H4: The Deepwater Horizon oil spill has a significant negative effect on the fleet riskiness of the firms*

The fourth hypothesis examines the effect of the Deepwater Horizon oil spill on the riskiness of the fleet size of the firms. Therefore, the regression is as follows:

$$Fleet\ Riskiness_{i,t} = \delta_t + \lambda_t + \alpha D_{it} + X(control\ variables)_{it} + \varepsilon_{i,t} \qquad (12)$$

4.4 Predictive Validity Framework



5. EMPIRICAL RESULTS AND ANALYSIS

This chapter starts by discussing the results of the event study. Furthermore, this chapters compares the key financial metrics of this study pre- and post-event, before elaborating on the results of the regression analysis regarding the difference-in-differences method.

5.1 The effect of the Deepwater Horizon oil spill on the firms' stock returns

Table IV shows the abnormal returns of the ten offshore oil drilling firms within an event period of -5 till +5 around the event day 0. Event day 0 marks the day the Deepwater Horizon oil spill occurred.

Table IV: Abnormal returns of the ten offshore oil drilling firms

This table presents the abnormal returns of the ten offshore oil drilling firms around the event of the Deepwater Horizon oil spill. The estimation period for this study is defined as day -244 till day -6, whereas the event period regards the period from day -5 till +5. Day 0 is defined as the day that the event occurred. Consequently, this study uses a maximum of 250 daily return observations. The S&P Oil & Gas Exploration & Production Select Industry Index (XOP) acts as the benchmark in the event study. Abnormal returns are denoted in percentages. * *p<0.10; ** p<0.05; *** p<0.01*.

	Atwood Oceanics		Diamond Offshore		Ensco		Helmerich & Payne		Hercules Offshore		Nabors Industries		Noble Corp		Parker Drilling		Rowan Companies		Transocean	
Event Day	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*	*AR%*	*T-stat*
-5	0.21	0.13	-0.14	-0.12	-1.00	-0.69	0.77	0.52	-2.78	-0.72	-0.36	-0.21	-0.01	-0.01	-9.41	-3.70***	-0.49	-0.31	-1.13	-0.91
-4	3.59	2.20**	1.54	1.34	3.44	2.36***	1.64	1.10	3.29	0.85	0.11	0.07	-0.81	-0.63	-2.45	-0.96	1.74	1.10	2.53	2.05**
-3	1.02	0.63	-1.55	-1.35	0.40	0.28	2.06	1.38	-0.48	-0.12	0.87	0.52	1.27	0.98	-0.13	-0.05	0.75	0.47	0.74	0.60
-2	-1.62	-0.99	-2.91	-2.52***	-1.24	-0.85	0.11	0.07	-0.33	-0.08	0.23	0.14	-1.83	-1.41	-0.51	-0.20	0.00	0.00	0.58	0.47
-1	0.72	0.44	1.24	1.07	0.86	0.59	0.07	0.05	-0.60	-0.16	1.65	0.99	0.21	0.16	1.07	0.42	0.85	0.53	2.07	1.68*
0	1.28	0.79	2.19	1.90*	0.46	0.31	0.71	0.48	2.86	0.74	0.85	0.51	2.13	1.64	-1.27	-0.50	1.75	1.10	2.55	2.07**
+1	-0.49	-0.30	-0.66	-0.58	-0.48	-0.33	3.99	2.67***	0.80	0.21	3.78	2.27**	3.97	1.56	-0.45	-0.34	0.09	0.06	-1.50	-1.22
+2	-0.18	-0.11	-6.05	-5.25***	3.16	2.17**	0.86	0.58	0.66	0.17	2.69	1.61	1.47	0.58	1.75	1.35	-0.54	-0.34	-0.75	-0.61
+3	-0.96	-0.59	-2.15	-1.86*	0.39	0.27	-2.10	-1.41	-0.52	-0.14	0.07	0.04	-1.53	-0.60	-0.59	-0.46	-1.38	-0.87	-2.77	-2.24**
+4	-1.71	-1.05	-0.14	-0.12	-0.64	-0.44	0.73	0.49	-2.37	-0.61	-2.87	-1.72*	0.05	0.04	-0.07	-0.03	-0.88	-0.56	-1.78	-1.44
+5	0.88	0.54	1.96	1.70*	1.15	0.79	0.09	0.06	1.43	0.37	-0.58	-0.35	-0.64	-0.49	1.42	0.56	-0.04	-0.02	-1.28	-1.03

The table shows that the shock of the Deepwater Horizon oil spill had a heterogeneous effect on the stock returns of the ten offshore oil drilling firms. Table IV shows that the shock of the Deepwater Horizon oil spill had a negative impact on the abnormal returns of Atwood Oceanics on event day +1, +2, and +3, with -0.49, -0.18, and -0.96 percent respectively. The same holds for Diamond Offshore with -0,66, -6.05, and 2.15 percent respectively. Ensco shows the opposite reaction in the aftermath of the oil spill. Although Ensco displays a negative reaction of -0.48 percent on event day +1, on event day +2 and +3 Ensco displays positive abnormal returns of 3.16 and 0.39 percent respectively. This implies that the shock of the oil spill is more severe for Atwood Oceanics and Diamond Offshore than for Ensco. Helmerich & Payne exhibits abnormal returns of 3.99, 0.86 and -2.10. Hercules Offshore shows abnormal returns of 0.80, 0.66, and -0.52. Nabors Industries displays positive abnormal returns of 3.78, 2.69, and 0.07 percent. Noble Corp exhibits abnormal returns of 3.97, 1.47, and -1.53. Parker Drilling shows abnormal returns of -0.45, 1.75, and -0.59 percent in the aftermath of the Deepwater Horizon oil spill. Rowan Companies displays abnormal returns of 0.09, -0.54, and -1.38 percent. Transocean shows negative abnormal returns with -1.50, -0.75, and -2.77 percent.

Table V: Cumulative abnormal returns of the ten offshore oil drilling firms

This table presents the cumulative abnormal returns of the ten offshore oil drilling firms around the event of the Deepwater Horizon oil spill. The estimation period for this study is defined as day -244 till day -6, whereas the event period regards the period from day -5 till +5. Day 0 is defined as the day that the event occurred. Consequently, this study uses a maximum of 250 daily return observations. The S&P Oil & Gas Exploration & Production Select Industry Index (XOP) acts as the benchmark in the event study. Cumulative abnormal returns are denoted in percentages.

	Atwood Oceanics	Diamond Offshore	Ensco	Helmerich & Payne	Hercules Offshore	Nabors Industries	Noble Corp	Parker Drilling	Rowan Companies	Transocean
Event Day	*CAR%*	*CAR%*	*CAR%*	*CAR%*	*CAR%*	*CAR%*	*CAR%*	*CAR%*	*CAR%*	*CAR%*
+1	-0.49	-0.66	-0.48	3.99	0.80	3.78	3.97	-0.45	0.09	-1.50
+2	-0.67	-6.71	2.68	4.85	1.46	6.47	5.44	1.30	-0.45	-2.25
+3	-1.63	-8.86	3.07	2.75	0.94	6.54	3.91	0.71	-1.83	-5.02

Table V displays the cumulative abnormal returns of the ten offshore oil drilling firms. The event period (+1, +3) is of interest for this study since this grasps the short-term effect of the shock of the Deepwater Horizon oil spill. Event day 0 is not included in the cumulative abnormal returns since the Deepwater Horizon oil spill happened around 9 pm on the event day. Atwood Oceanics, Diamond Offshore, Rowan Companies, and Transocean all show that the Deepwater Horizon oil spill had a negative effect of the stock returns of these firms. This effect is less severe, with positive cumulative abnormal returns, for Ensco, Helmerich & Payne, Hercules Offshore, Nabors Industries, Noble Corp, and Parker Drilling on event day +3. This regression shows us the effect of the shock of the Deepwater Horizon oil spill on the offshore oil drilling firms. One can conclude that the shock of the Deepwater Horizon oil spill indeed is heterogeneous, which can be observed because the firms show different abnormal returns around the event of the Deepwater Horizon oil spill. The abnormal returns exhibit a slightly positive effect but close to zero, on average, which means the effect of the shock of the oil spill is not as negative as one expected it to be. The result of this regression also acts as the measurement for the construction of the treatment and control group for the regressions of the capital investments of the firms. Based on the cumulative abnormal returns, the treatment group consists of Atwood Oceanics, Diamond Offshore, Parker Drilling, Rowan Companies, and Transocean. The control group consists of Ensco, Helmerich & Payne, Hercules Offshore, Nabors Industries, and Noble Corp.

5.2 Pre– and post-event comparison of key financial metrics

Table VI shows the average disposition of assets to total assets (in million US dollars) before and after the Deepwater Horizon oil spill, and the difference between the two periods. The table provides evidence that the shock of the Deepwater Horizon oil spill is different for firms, which means that the shock had a heterogeneous effect within the oil drilling industry. Ensco Plc, Hercules Offshore Inc, and Nabors Industries Ltd have increased their disposition of assets, on average, after the Deepwater Horizon oil spill, with 0.002, 0.019, and 0.008 respectively. Whereas the rest have decreased their disposition of assets, on average. The highest differences in disposition of assets regards Hercules Offshore Inc and Parker Drilling Co, with 0.019 and -0.029 respectively. This would imply that these two firms have experienced the biggest shock when considering the disposition of assets.

Table VI: Average disposition of assets pre- and post-Deepwater Horizon oil spill

This table presents the average disposition of assets divided by total assets of each firm before and after the Deepwater Horizon oil spill (2010), where delta reflects the difference between the two periods. The amounts reported in the table are denoted in million US dollars. The second and third column, respectively, reflect the period before and after the Deepwater Horizon oil spill. The last column represents the delta between these two periods.

Firm	Before (2005-2009)	After (2011-2015)	Delta (Δ)
Atwood Oceanics Inc	0.004	0.003	-0.001
Diamond Offshore Drilling Inc	0.007	0.005	-0.002
Ensco Plc	0.001	0.003	0.002
Helmerich & Payne Inc	0.008	0.005	-0.003
Hercules Offshore Inc	0.012	0.031	0.019

Nabors Industries Ltd	0.006	0.014	0.008
Noble Corp Plc	0.002	0.001	-0.001
Parker Drilling Co	0.033	0.004	-0.029
Rowan Companies Plc	0.013	0.003	-0.010
Transocean Ltd	0.014	0.004	-0.010

Table VII shows the average capital expenditure to total assets (in US million dollars) before and after the Deepwater Horizon oil spill, and the difference between the two periods. The table exhibits that the Deepwater Horizon oil spill had a different effect on the firms when taking capital expenditure into account, implying that the shock is different within the oil drilling industry. Atwood Oceanics Inc, Rowan Companies Plc, and Transocean Ltd show a positive delta for capital expenditure, with 0.021, 0.019, and 0.002 respectively, which means that these firms increased their capital expenditure, on average, after the Deepwater Horizon oil spill. Whereas all the other firms have a negative delta. Hercules Offshore Inc shows the biggest delta with -0.125, which would imply that Hercules Offshore Inc experienced the biggest shock due to the Deepwater Horizon oil spill.

Table VII: Average capital expenditure pre- and post-Deepwater Horizon oil spill

This table presents the average capital expenditure divided by total assets of each firm before and after the Deepwater Horizon oil spill (2010), where delta reflects the difference between the two periods. The amounts reported in the table are denoted in million US dollars. The second and third column, respectively, reflect the period before and after the Deepwater Horizon oil spill. The last column represents the delta between these two periods.

Firm	Before (2005-2009)	After (2011-2015)	Delta (Δ)
Atwood Oceanics Inc	0.178	0.199	0.021
Diamond Offshore Drilling Inc	0.143	0.138	-0.005
Ensco Plc	0.124	0.089	-0.035
Helmerich & Payne Inc	0.193	0.152	-0.041
Hercules Offshore Inc	0.223	0.098	-0.125
Nabors Industries Ltd	0.156	0.124	-0.032
Noble Corp Plc	0.180	0.131	-0.049
Parker Drilling Co	0.164	0.119	-0.045
Rowan Companies Plc	0.124	0.143	0.019
Transocean Ltd	0.056	0.058	0.002

Table VIII shows the average fleet size (in number of drillships) before and after the Deepwater Horizon oil spill, and the difference between the two periods. The table provides evidence that the firms reacted differently after the Deepwater Horizon oil spill, considering their fleet size. Atwood Oceanics Inc, Hercules Offshore Inc, and Rowan Companies Plc show a positive difference after the Deepwater Horizon oil spill, whereas the rest displays a negative difference, except for Helmerich & Payne Inc that did not change their fleet size, on average. Ensco Plc and Transocean Ltd show the biggest difference in fleet size between the two periods, with 26 and -27 respectively, which would imply they experienced the biggest shock due to the Deepwater Horizon oil spill. However, Ensco Plc acquired Pride International in 2011, adding their fleet size with the drillships of Pride International. Hence, this increase could give a distorted display of the reality.

Table VIII: Average fleet size pre- and post-Deepwater Horizon oil spill

This table presents the average fleet size of each firm before and after the Deepwater Horizon oil spill (2010), where delta reflects the difference between the two periods. The amounts reported in the table are denoted in number of drillships held by the firm at the time. The second and third column, respectively, reflect the period before and after the Deepwater Horizon oil spill. The last column represents the delta between these two periods.

*Ensco Plc is subject to an acquisition of Pride International in 2011, hence the large increase in fleet size.

Firm	Before (2005-2009)	After (2011-2015)	Delta (Δ)
Atwood Oceanics Inc	8	11	3
Diamond Offshore Drilling Inc	45	42	-3
Ensco Plc	46	72	26*
Helmerich & Payne Inc	9	9	0
Hercules Offshore Inc	37	42	5
Nabors Industries Ltd	15	9	-6
Noble Corp Plc	62	58	-4
Parker Drilling Co	17	14	-3
Rowan Companies Plc	21	31	10
Transocean Ltd	112	85	-27

Table IX shows the average fleet riskiness, which is the portion of deepwater drillships divided by the total fleet size (denoted in point percentages), before and after the Deepwater Horizon oil spill, and the difference between the two periods. The table shows that the firms responded differently after the Deepwater Horizon oil spill. This would imply that the shock of the Deepwater Horizon oil spill had a different effect within the oil drilling industry. Atwood Oceanics Inc and Hercules Offshore Inc show a negative delta regarding the average fleet riskiness, with -0.08 and -0.014 respectively. Whereas all the other firms show a positive delta, apart from Helmerich & Payne which shows no difference on average. Ensco Plc shows the biggest delta of 0.31-point percentage, which means an increase of 31 percent in their fleet riskiness, on average. This would imply they experienced the biggest shock due to the Deepwater Horizon oil spill, considering the average fleet riskiness of the firm.

Table IX: Average fleet riskiness pre- and post-Deepwater Horizon oil spill

This table presents the average fleet riskiness of each firm before and after the Deepwater Horizon oil spill (2010), where delta reflects the difference between the two periods. The amounts reported in the table are denoted in point percentages. The second and third column, respectively, reflect the period before and after the Deepwater Horizon oil spill. The last column represents the delta between these two periods.

Firm	Before (2005-2009)	After (2011-2015)	Delta (Δ)
Atwood Oceanics Inc	0.61	0.53	-0.08
Diamond Offshore Drilling Inc	0.25	0.47	0.22
Ensco Plc	0.07	0.38	0.31
Helmerich & Payne Inc	1.00	1.00	0.00
Hercules Offshore Inc	0.26	0.12	-0.14
Nabors Industries Ltd	0.00	0.00	0.00
Noble Corp Plc	0.26	0.39	0.13
Parker Drilling Co	0.60	0.73	0.13
Rowan Companies Plc	0.00	0.05	0.05
Transocean Ltd	0.35	0.56	0.21

Table X shows the industry-differences of the key financial metrics before and after the Deepwater Horizon oil spill. The table shows that the disposition of assets decreased on average, on industry level. This would imply that the oil drilling industry, on average, did not increase their disposition of assets in the period after the Deepwater Horizon oil spill. Furthermore, the table exhibits that the average capital expenditure decreased on industry level. This would imply that the oil drilling industry did decrease their investments in the period after the Deepwater Horizon oil spill. In addition, the table displays no difference in fleet size on industry level, on average. Lastly, the table shows that the industry increased their fleet riskiness in the period after the Deepwater Horizon oil spill. This would imply that the offshore oil drilling industry did not change their fleet size but did change the riskiness of their fleet.

Table X: Industry-differences of the key financial metrics pre- and post-Deepwater Horizon oil spill

This table presents the industry-differences of the key financial metrics before and after Deepwater Horizon oil spill (2010), where delta reflects the difference between the two periods. *Disposition of Assets* and *Capital Expenditure* are both divided by total assets and are both denoted in US million dollars. *Fleet Size* is the number of drillships that is held by the firms. *Fleet Riskiness* reflects the portion of deepwater drillships to total fleet size and is denoted in point percentages. The second and third column, respectively, reflect the period before and after the Deepwater Horizon oil spill. The last column represents the delta between these two periods.

Variable	Before (2005-2009)	After (2011-2015)	Delta (Δ)
Disposition of Assets	0.010	0.007	-0.003
Capital Expenditure	0.154	0.125	-0.029
Fleet Size	37	37	0
Fleet Riskiness	0.34	0.42	0.08

5.3 The effect of the Deepwater Horizon oil spill on the firms' capital investments

The previous section implies that the responses in the period after the Deepwater Horizon oil spill were different among the offshore oil drilling firms. However, this yet shows if the shock of the Deepwater Horizon oil spill influenced these effects. Consequently, this section elaborates on the regressions that are run to examine if there exists a relationship.

Table XI: The effect of the shock of the Deepwater Horizon oil spill on the firms' capital investments

This table presents the relationship between the shock of the Deepwater Horizon oil spill and the four dimensions of capital investments: (1) disposition of assets, (2) capital expenditure, (3) fleet size, (4) fleet riskiness. *Treatment* represents a dummy variable which has the value one for the treatment group and the value zero for the control group. *Time* reflects a dummy variable which has the value one for the period after the event and zero for the period before the event. *DiD* is the difference-in-differences estimator which captures the possible difference between the treatment and control group after the shock of the Deepwater Horizon oil spill. Standard errors are reported in parentheses. * $p<0.10$; ** $p<0.05$; *** $p<0.01$.

	(1)	(2)	(3)	(4)
Variable	Disposition of Assets	Capital Expenditure	Fleet Size	Fleet Riskiness
Treatment	0.009***	-0.031	-1.70	-0.020
	(0.003)	(0.022)	(6.12)	(0.839)
Time	0.007*	-0.040*	-0.74	0.138
	(0.003)	(0.218)	(6.09)	(0.084)
DiD	-0.014***	0.061**	-13.19	0.029
	(0.005)	(0.294)	(8.20)	(0.112)
Book Leverage	0.011***	-0.032*	25.49***	-0.027
	(0.003)	(0.018)	(4.89)	(0.067)
Sales	-0.010	0.081	-106.45***	1.614***
	(0.015)	(0.094)	(26.23)	(0.360)
Profitability (ROA)	0.059*	0.107	113.48**	-0.839
	(0.032)	(0.204)	(56.87)	(0.780)
Dividends	-0.097***	0.060	-7.33	-0.765
	(0.035)	(0.221)	(61.71)	(0.846)
General Expenses	0.174	0.832	-1233.49***	-12.344***
	(0.114)	(0.723)	(201.71)	(2.767)
Constant	-0.011*	0.106***	73.62***	0.098
	(0.006)	0.037	(10.20)	(0.140)
Observations	100	100	100	100
R^2	0.308	0.206	0.619	0.297
Adjusted R^2	0.248	0.137	0.586	0.235
F-statistic	5.07	2.96	18.51	4.81
P-value (F)	0.0000	0.0055	0.0000	0.0001

5.3.1 Disposition of Assets

Table XI shows the regression regarding the relationship between the Deepwater Horizon oil spill and the firms´ capital investments. Column one examines the first hypothesis: the Deepwater Horizon oil spill has a significant positive effect on the disposition of assets of the firms, meaning that firms increase their disposition of assets because of the Deepwater Horizon oil spill. The treatment dummy is the estimated mean difference in the disposition of the assets between the treatment and control group before the Deepwater Horizon oil spill occurred. The time dummy is the effect of the passage of time in the absence of the Deepwater Horizon oil spill. DiD is the difference-in-differences estimator which provides evidence if there is a difference in the estimated mean in disposition of assets after the Deepwater Horizon oil spill for the two groups.

The treatment dummy for disposition of assets is 0.009, which implies that before the Deepwater Horizon oil spill took place that the treatment group had a higher level of disposition of assets, on average, than the control group, and is highly significant. The time dummy reflects a positive effect for the control group, which is 0.007 and significant at a 10% significance level. The table shows that book leverage is positively correlated with disposition of assets, with a coefficient of 0.011 at a 1% significance level. In addition, profitability is positively correlated with disposition of assets, with a coefficient of 0.059 at a 10% significance level. Furthermore, dividends is negatively correlated with disposition of assets, with a coefficient of -0.097 at a 1% significance level. The regression provides a DiD estimator of -0.014, which is significant at a 1% level. This implies that the effect of the Deepwater Horizon oil spill is significantly smaller for the treatment group than for the control group. The total effect for the treatment group is -0.005, which is smaller but still negative. This means that the treatment group had, on average, a lower level of disposition of assets than the control group after the Deepwater Horizon oil spill. This result is odd since one would expect the group with the higher exposure to the shock of the Deepwater Horizon oil spill, to increase their disposition of assets significantly more than the group with the lower exposure to strengthen their capital stock, but the opposite is true.

5.3.2 Capital Expenditure

Table XI also shows the regression regarding the relationship between the Deepwater Horizon oil spill and capital expenditure. This examines the second hypothesis: the Deepwater Horizon oil spill has a significant negative effect on the capital expenditure of the firms, meaning that firms decrease their capital expenditure because of the Deepwater Horizon oil spill.

The table shows that book leverage is negatively correlated with capital expenditure, with -0.032 at a 10% significance level. The time dummy reflects the negative effect for the control group, which is -0.040 and significant at a 10% level. The treatment dummy, which is the estimated mean difference in the disposition of the assets between the treatment and control group before the Deepwater Horizon oil spill occurred, is -0.031 but not significant. This implies that before the Deepwater Horizon oil spill took place that the treatment group had a lower level of capital expenditure, on average, than the control group. However, the DiD estimator is 0.061, which is significant at a 5% level. This implies that the effect of the Deepwater Horizon oil spill is significantly higher for the treatment group than for the control group. The total effect for the treatment group is the sum of the treatment dummy and the DiD estimator, which is 0.030. Consequently, the effect is lower but still positive. This means that the group with the higher exposure to the shock of the Deepwater Horizon oil spill significantly increased their capital expenditure, on average, after the oil spill occurred. This is not in line with what one would expect since one would expect the firms with the higher exposure to the shock to decrease their capital expenditure due to uncertainty and the instability after the oil spill. On the contrary, it shows that the firms with the higher exposure to the shock of the Deepwater Horizon oil spill tend to increase their capital investments in the period after the oil spill occurred.

5.3.3 Fleet Size

Column three of table XI shows the regression regarding the relationship between the Deepwater Horizon oil spill and the fleet size of the firms. This examines the third hypothesis: the Deepwater Horizon oil spill has a significant negative effect on the fleet size of the firms, meaning that firms reduce the size of their fleet because of the Deepwater Horizon oil spill.

The table shows that book leverage is positively correlated with fleet size with 25.49 at a 1% significance level. In addition, sales are negatively correlated with fleet size, with -106.45 at a significance level of 1%. Moreover, profitability is positively correlated with fleet size, with 113.48 at a 5% significance level. Lastly, general expenses are negatively correlated with fleet size, with -1233.49 at a significance level of 1%. The time dummy reflects the negative effect for the control group, which is -0.74. The treatment dummy is -1.74 which implies a negative relationship for the treatment group. This would imply that before the Deepwater Horizon oil spill took place, the treatment group had a lower fleet size, on average, than the control group. Moreover, the DiD estimator is -13.19. This implies that the effect of the Deepwater Horizon oil spill is significantly stronger for the treatment group than for the control group. The total effect for the treatment group is the sum of the treatment dummy and the DiD estimator, which is -14.93. This means that the group with the higher exposure to the shock of the Deepwater Horizon oil spill significantly reduced their fleet size after the oil spill occurred. The fact that the treatment had a much smaller fleet size after the oil spill than before, shows that the Deepwater Horizon oil spill indeed influenced the fleet size of the firms involved. This is in line with what one would expect since one would expect the firms with the higher exposure to the shock of the Deepwater Horizon oil spill to reduce their fleet size. However, the regression does not provide significant results for this relationship. Therefore, one cannot conclude that the shock of the Deepwater Horizon oil spill influenced the fleet size of the firms.

5.3.4 Fleet Riskiness

Column four of table XI shows the regression regarding the relationship between the Deepwater Horizon oil spill and the fleet riskiness of the firms. This examines the fourth and last hypothesis: the Deepwater Horizon oil spill has a significant negative effect on the fleet riskiness of the firms, meaning that firms decrease their portion of deepwater drillships of the total fleet size because of the Deepwater Horizon oil spill.

The table shows that sales is positively correlated with fleet riskiness, with 1.614 at a 1% significance level. In addition, general expenses show to be significantly and negatively correlated with fleet riskiness, with -12.344 at a 1% significance level. The time dummy reflects the positive effect for the control group, which is 0.138. The treatment dummy is -0.020, which would imply that before the Deepwater Horizon oil spill took place that the treatment group had a lower level of fleet riskiness, on average, than the control group. However, the DiD estimator is 0.029. This means that the group with the higher exposure to the shock of the Deepwater Horizon oil spill increased their level of fleet riskiness after the oil spill occurred. This is not in line with what one would expect since one would expect the firms with the higher exposure to the shock to reduce their fleet riskiness. However, this result is not significant. Therefore, one cannot conclude that the shock of the Deepwater Horizon oil spill influenced the level of fleet riskiness of the firms.

6. CONCLUSION

This study has examined the effect of the shock of the Deepwater Horizon oil spill on the offshore oil drilling firms in the U.S. Gulf of Mexico and their capital investments. Specifically, the research question of this study is: has the Deepwater Horizon oil spill suppressed the capital investments of the offshore oil drilling firms? This study focuses on four dimensions to analyze this relationship, namely disposition of assets, capital expenditure, fleet size, and fleet riskiness.

This study finds that the effect of the shock of the Deepwater Horizon oil spill, on average, was slightly positive but close to zero, regarding the cumulative abnormal returns of the offshore oil drilling firms. The results provide evidence that the offshore oil drilling firms tend to reduce their disposition of assets after the Deepwater Horizon oil spill. Moreover, these firms tend to increase their capital expenditure in the period following the Deepwater Horizon oil spill. There is no significant evidence that the fleet size and fleet riskiness are affected by the shock of the Deepwater Horizon oil spill. Therefore, this will be excluded from the main conclusion of the study.

Since the oil drilling firms, on average, did increase their capital investments when considering the disposition of assets and capital expenditure of the firms, one can say that the Deepwater Horizon oil spill has not suppressed the capital investments of these firms but to surprise, stimulated the level of capital investments of these firms. Possible explanations could be the acquisition of better and safer machinery and equipment due to the pressure of the public and the U.S. government, the mergers and acquisitions that took place after the Deepwater Horizon oil spill as a mean to survive. In addition, the fact that in times of financial distress prices of assets tend to be below the book value could be an explanation for the reluctance to dispose assets.

This study has contributed to the existing literature by examining the effect of an oil spill on the capital investments of the associated industry, in this case the Deepwater Horizon oil spill and the oil drilling industry, since there was little evidence on this matter. Although a lot of thought and effort is put into this study, there exists some limitations that could be suggestions for further research. Firstly, this study is conducted with ten offshore oil drilling firms that are active in the US GOM. Therefore, it is not fully representative for the oil drilling industry as a whole. Besides, the outcome of this study could be influenced by certain area-specific components. Further research could seek to expand this research to a broader perspective and take environmental influences into account. Secondly, the difference-in-differences method could cause some biases, such as reverse causality and omitted variable bias. Therefore, it could be interesting to examine this relationship with a different methodology.

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8. APPENDIX

Table XII: List of Firms

This table shows 50 firms that possibly fit the criteria of this study, namely: (1) offshore oil drilling activity, (2) active in the US GOM from at least 2005 till 2015, (3) availability of information on disposition of assets, capital expenditure and fleet size. The list of firms is reduced to ten firms based on these criteria. Moreover, the table provides the firm's ticker and cusip code.

Firm	Ticker	Cusip	Firm	Ticker	Cusip
Allis-Chalmers Energy Inc	ALY	01964550	Ocean Rig UDW Inc	ORIG	G6696411
Archrock Partners LP	APLP	03957U10	Oceaneering International	OII	67523210
Atwood Oceanics Inc	ATW	05009510	Omni Energy Services Corp	OMNI	68210T20
Baker Hughes Inc	BHI	05722410	Pacific Drilling SA	PACDQ	L7257P11
Basic Energy Services Inc	BAS	06985P20	Parker Drilling Co	PKD	70108110
BJ Services Co	BJS.1	05548210	Patterson-Uti Energy Inc	PTEN	70348110
Bronco Drilling Co	BRNC	11221110	Pioneer Energy Services Corp	PES	72366410
Cal Dive International Inc	CDVIQ	12802T10	Precision Drilling Corp	PDS	74022D30
Core Laboratories NY	CLB	N2271710	Pride International Inc	PDE	74153Q10
CSI Compressco LP	CCLP	12637A10	Rowan Companies Plc	RDC	G7665A10
Dawson Geophysical Co	DWSN	23936010	RPC Inc	RES	74966010
Diamond Offshore Drilling Inc	DO	25271C10	Schlumberger Ltd	SLB	80685710
Ensco Plc	ESV	G3157S10	Seadrill Ltd	SDRL	G7945E10
Forbes Energy Services Ltd	FESLQ	34514310	Seahawk Drilling Inc	HAWKQ	81201R10
Global Geophysical Svcs Inc	GEGSQ	37946S10	Seventy Seven Energy Inc	SVNT	81809A10
GL Industries Ltd	GLBL.1	37933610	Sinotech Energy Ltd	CTESY	82935910
Greenhunter Resources Inc	GRHHQ	39530A10	Steel Excel Inc	SXCL	85812220
Halliburton Co	HAL	40621610	Superior Energy Services Inc	SPN	86815710
Helix Energy Solutions Group	HLX	42330P10	Superior Well Services Inc	SWSI.	86837X10
Helmerich & Payne Inc	HP	42345210	Tetra Technologies Inc/De	TTI	88162F10
Hercules Offshore Inc	HEROQ	42709330	Transocean Ltd	RIG	H8817H10
Key Energy Services Inc	KEG	49309J10	Union Drilling Inc	UDRL	90653P10
Nabors Industries Ltd	NBR	G6359F10	Vantage Drilling Co	VTGDF	G9320511
Noble Corp Plc	NE	G6543110	Weatherford Intl Plc	WFT	G4883310