Pros and Cons of Oil and Gas Exploration in Lofoten

Submitted by: Asludin Aliye Ebrahim and S M Tanveer Ahmed

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Pros and Cons of Oil and Gas Exploration in Lofoten.

AUTHOR(S)		SUPERVISOR:
Candidate number:	Name:	Gorm Kipperberg
4036 …………………	Asludin Aliye Ebrahim ……………………………..	
4118 …………………	S M Tanveer Ahmed ………………………………..	

Preface:

The study "Pros and Cons of Oil and Gas Exploration in Lofoten" is the master thesis for the semester Spring 2019 at the University of Stavanger. As an essential part of our Msc in Business Administration program, this master thesis has been done by two of us and carries 30 credits. We are Asludin Aliye Ebrahim and S M Tanveer Ahmed, majoring in Economies and Business Innovation respectively and produced this thesis together with an ambition to contribute to the Norwegian petroleum sector and policy making. Our intention was to create an optimal cost-benefit analysis on Lofoten petroleum exploration that can be seen as a starting point for further research.

First of all, we would like to express our sincere gratitude to our respected supervisor Gorm Kipperberg for his valuable guidance and mentorship through the course of our thesis. From the very beginning of the thesis to the very end he was so helpful and supporting us and continuously motivated us. We would also like to express our appreciation to Prof. Klaus Mohn for valuable advice and inputs. Heartful, thanks to Mursit Cetin from Norwegian Directorate of Fishery for showing us the valuable data source.

We would also like to tank to our family and friends for the support during our thesis.

Regards,

Asludin Aliye Ebrahim (ID:243380)

&

S M Tanveer Ahmed (ID: 243990)

July 2019
University of Stavanger (UiS)
Stavanger, Norway.

Abstract:

The aim of the study is to logically respond to the ongoing dilemma on Lofoten that whether Lofoten should be open for oil and gas extraction based on cost-benefit analysis. So far, our knowledge is concerning a little attempt that has been made to evaluate the Lofoten area by considering all possible costs and benefits by conducting an optimal cost benefit analysis.

Net Present Value (NPV) method is used to analyse the net effects after collecting and processing the secondary data. It is a 50 years projection from 2020 to 2070 and therefore previous data are extensively used to project future cash flows, which were discounted by 3% rate which is also the rate of return from the Norwegian Government Pension Fund Global (GPFG). The direct benefit from oil and gas extraction, possible indirect losses from fishing and tourism, expected petroleum supply sector benefit, possible oil spill and clean-up costs and environmental cost are the basic factor that has been taken into consideration during the course of the study. Net costs are deducted from the net benefit we come up with a negative value (net loss) of NOK 1.71 billion. That indicates that considering the aforementioned factors if oil and gas extraction is allowed in Lofoten area the ,Norwegian government will incur a loss of NOK 1.71 billion over the next 50-year period. Therefore, the answer of the question of "whether Lofoten should be open for oil and gas extraction" is "No" according to our finding. In addition, we also suggested the avenue for future researches by presenting the fact that our study hasn't taken into account.

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Acronyms:

BIH- Bird in Hand approach.

BP- British Petroleum.

bn- Billion.

boe- barrel of oil equivalence.

bbl- Barrel of oil.

BTU- British Thermal Unit.

CBA- Cost-Benefit Analysis.

CO2- Carbon dioxide

DCF- Discounted Cash Flow.

DWL- Dead Weight Loss.

EBITDA- Earnings before Interest and Tax + Depreciation and Amortization.

GDP- Gross Domestic Product.

GPFG- Government Pension Fund-Global.

GHG- Green House Gas

IRENA – International Renewable Energy Agency.

IOPCF - International Oil Pollution Compensation Fund

IEA- International Energy Agency.

LBS- Lofoten-Barents Sea.

MT- Metric ton.

NCF- Norwegian Continental Shelf.

NOK- Norwegian Kroner.

NPD- Norwegian Petroleum Direktoret.

NPV-Net Present Value.

PIH- Permanent Income Hypothesis.

SBU- Strategic Business Unit.

SSB- Statistisk Sentralbyrå (Statistic Norway)

Sm^3- Standard Cubic Meter.

USD- United States Dollar.

WTA/WTP- Willingness to Accept/ Willingness to Pay.

Part One: Introduction

The oil and gas industry is by far the largest exporting sector in Norway with positive productivity spillovers on other non-resource and non-traded sectors. During the last decades, oil and gas exports have made up around 50% of the total Norwegian export value. The oil and gas industry is also the largest contributor to the Norwegian GDP with a share around 20% (Tveterås R.2018).

In a move that looks apparently against and basically disregard the facts mentioned in the above paragraph, one might also hear the shocking fact that Norway has banned oil and gas production in a special part of its continental shelf called the Lofoten region and insists in its decision to keep the region intact. Nothing looks more absurd than hearing such general statement that an oil rich Scandinavian country has passed a law, which prevents oil companies from getting access to the region and thereby the country is obliged to lose employment and huge revenue from the sector. One might even be more surprised when he/she becomes aware of the fact that the country is one of the world's major oil producer and is the largest gas producer in Europe. This puzzle is no exceptions for us as researcher to make us jump in to the complex and chaos of investigation why the country did so. Hereby, at this early stage, in this introduction part some basic information will be presented so that we believe smooth reading and easy understanding will prevail for whomever interested in fetching out the rationale behind. For this reason, a brief overview of the Norwegian economy and the oil sector takes precedence to show the level of importance of oil sector. A resulting problem statement together with research questions logically follows; to answer these questions research design used will precisely be described in the part that follows; significance of the research will be highlighted and discussed as integral part to show how relevant this thesis is. Followed by the overview of the chapters will be presented by giving emphasis to the description of theories and related literatures to show how relevant they are before finalizing this part .

Norway as a Scandinavian country used to follow its Scandinavian neighbors in its economic performance since its inception as a sovereign nation before petroleum era. An introduction of a miraculous resource has been brought into Norwegian economy in 1969, when the discovery of oil was announced to change its economic history for once and perhaps forever (Larsen, 2006). As a result of which it took Norway only two decades to surpass Sweden and Denmark in its GDP and to achieve major successes in socio-economic scenes. It didn't take longer before the oil sector become a pioneering motor to steer the remaining sector of Norwegian economy. It stands first in representing Norwegian export economy and the largest single to create largest employment opportunity to the nation with tremendous impact on other sector in the value-chain. Norwegians are also known to be successful in properly managing their oil revenue by establishing a fund mechanism that enables even future generation to be beneficent from the wealth that the nation is endowed (Mohn, 2016). This fund mechanism is owned by the government and is the single largest state-owned fund in the world (Visbeck , et al., 2017).

Thanks to the vast continental shelf that Norway has ,which is believed to be as three times as the mainland, major economic achievements have been made possible and successful welfare society has been established more importantly by the revenues generated from this area. It ranges from the southern part of Norway and extends all along to the northern part of Norway. Norwegians divide this continental shelf basically into three as the Northern sea, Norwegian sea; and the Barents Sea. Oil discovery operation was started in the southern part of Norway with the purpose of avoiding the harsh environmental condition that exists in the north; escape the challenges of technological inefficiency and thereby minimizing corresponding costs. By and large, however, as more and more fields in the North Sea depleted and technological advancement is achieved and enough skill to operate petroleum is accumulated, the country is moving north to Norwegian sea where it had already developed 16 producing fields and more others are being developed.

World energy hunger coupled with accumulated knowledge to extract petroleum even under the harshest environmental condition, forced the nation to go further north to the Barents Sea, where the process of extraction has already begun, and more companies are expected to join sooner. All these heated petroleum activities are not being made without ignoring a resource rich region which exists between the Norwegian and the Barents Sea, which is called the Lofoten region. At the time when world energy demand is souring, so many nations have begun exploring petroleum in their respective geographical regions; the legality of petroleum extraction after few decades is under question. So many countries are working on renewable energy technologies extensively to avoid dependence on fossil fuels and accordingly resource rich countries are expanding their production to avoid the risk. It is a puzzle that the Norwegian government prefers to keep the region free of petroleum extraction. Let’s find out why?

Relentless effort that have been made by Norwegian government exhaustively with the purpose of getting every drop of petroleum almost in all parts of its continental shelf ironically exceptionalism the Lofoten region and kept the region close for oil companies for so long.

The problem that this study tries to address is “should Lofoten region be opened for petroleum extraction?” based on the proposed research question we, as researchers we try to answer the following questions

1. What is the direct cost and benefit of petroleum activities incase commenced in the region?

2. What is net indirect cost and benefit of petroleum activities incase commenced in the region?

3. What is the amount of externality related to petroleum activity in the region?

In addition to trying to respond to our basic research question, this research work tries to fill the gap that previous studies didn’t cover and thereby we feel we could contribute a tiny to the broad body of knowledge.

We have seen that there are a number of studies that have been made reflecting different aspects of the region under consideration. For example, revenue and cost information relating to the envisaged project in the region has been described by Mohn (2019). There are also studies that describe economic importance of tourism (Bajada , 2016) (Amundsen, 2012) (Xie & Tveterås , 2018) and fishing (Høgi, 2010) (Misund & Olsen, 2013) sectors in the region. But to our knowledge, there is no single research work that brings these independent research works together in a meaningful way to enable an informed decision on petroleum extraction in the region. Conduct an optimal cost benefit analysis is what we are intended for and there was a gap of such kind of research where all the relevant effects that stem from new petroleum activities in Lofoten area taken into account (Mohn,2019). Establishing the petroleum industry into a new area has a multidimensional effect. From government policy and macro economical level to the life of an individual of the Loften, the area will be affected by the consequences. Some of the effects are positive and some are negative. Additional petroleum revenue and new employment opportunity some of the positive impact and income losses form fishing revenue and tourism are an example of two negative impacts. It has been observed that there is an absence of any research which has taken all these effects into one calculation and come-up with a final decision. The main strength of the study from our point of view is that we attempt to answer the main research question by identifying an optimal cost-benefit analysis.

This thesis is structured as follows: chapter two and chapter three establishes a conceptual framework by presenting theoretical positioning and summarizing some relevant previous studies. Chapter five describes the design and methodological approach of the thesis. This is followed by the major part of the analysis in chapter six where we discussed cost benefit analysis of oil project in the Lofoten region. The analysis undergoes three step analysis including direct effect analysis; indirect effect analysis and externality analysis. Chapter seven which is basically a discussion part is dedicated to discussing and summarizing the results and findings we came across in chapter six. Chapter eight is the last chapter and is a bottleneck of our long journey to come finally to the conclusion.

Part Two: Background of the Study

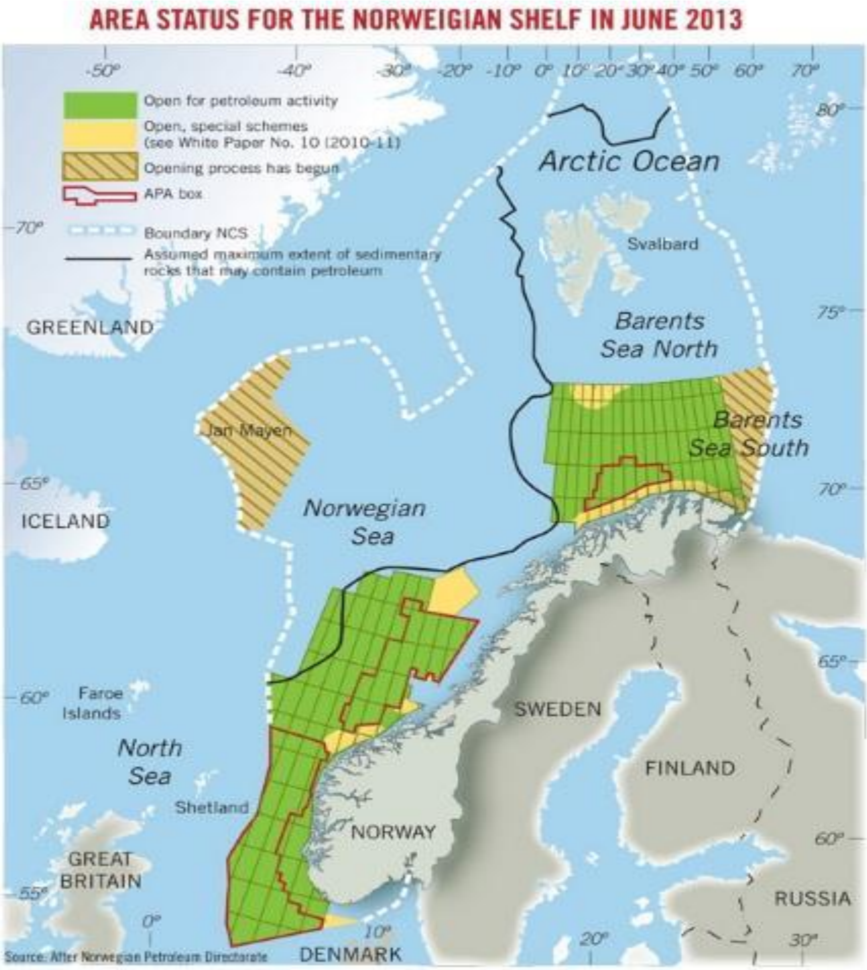
2.1 Overview of The Norwegian Economy and The Petroleum Industry:

Since the beginning of the Norwegian petroleum journey in 1969, Norway has been a flame example of a well managed economy with a properly executed investment policy of petroleum revenue. After the first oil discovery in 1969 Norwegian government decided to execute a policy for designing a properly utilized oil revenue for the benefit of the state as well as the people named Government Pension Fund- Global (GPFG) and adopted by 1990. Currently, GPFG has valued almost NOK 0.91 trillion in 2019 and the value reached up to the highest pick to NOK 1 trillion during 2017 (NORGES BANK INVESTMENT MANAGEMENT, 2019). At the outset, the petroleum exploration was initiated by the foreign company since 1963. However, later Norwegian state-owned petroleum company was established to reap the maximum benefit. As a continuation of that Statoil which is currently known as Equinor was established with sole government ownership in 1972. The purpose of Statoil is to provide a license to the oil companies with a condition of

keeping 50 percent ownership interest on each production. Nevertheless, Statoil was partially privatized in 2001. Including local and foreign companies more than 50 companies have been active on the Norwegian Continental Shelf (Fact, 2014). The Norwegian petroleum industry is the largest industry of Norway around 49 percent of total export value generated by this sector in 2013. Moreover, this sector is also leading to value creation and state revenue. Since the beginning of oil 1970 to 2013 petroleum sector has generated around NOK 11,000 billion in the economy. And the tax collected from this sector goes to the GPFG. During 2012 Norway was ranked the 3rd largest gas exporter and 10th largest oil exporter around the world. Till 2013 the number of people employed in this sector was around 250,000. According to Norges Bank (2019), GPFG investment is segregated into 3 different sectors among 9158 companies around 73 different countries in the world. The investment sectors are equity, bonds and real estate. The first quarter of 2019 the portion of equity, bonds, and real estate investment were 69.2%, 2.8%, and 28% respectively. With an impressive average return of 9.1%. Return on investment on equity 12.2 percent where the strongest return is coming from North American investment. As to mention Apple, Nestlé, Microsoft, and Samsung are few of the renowned companies where GPFG is invested. Real estate investment has a 4.9 percent return on investment. Followed by a 2.9 percent return from fixed income investment or bond investment, where the return on investment from UK guild and that is 2.5 percent (NORGES BANK INVESTMENT MANAGEMENT, 2019). GPFG often refer as SBU's real return it consists of net cash flows from petroleum activities and return on fund investment then the amount of fiscal budget deficit is deducted from generated cash inflows.

2.2 Norwegian Continental Shelf:

Generally speaking, the process of oil exploration and extraction is done either onshore or offshore; and sometimes can be done both onshore and offshore based upon the special geographic condition of the resource endowed nations. Norwegian petroleum exploration and extraction is dominated primarily by offshore activities with processing is basically done onshore. The following map provides an overall view of the Norwegian continental shelf and some peculiar characteristics of its regions.



Source: Oil and Gas Journal 2013

FIGURE 1: NCF PETROLEUM ACTIVITY STATUS.

The Norwegian continental shelf, consisting of three main sea regions of the North Sea, the Norwegian Sea, and the Barents Sea, is the petroleum hub of the country from which tremendous oil revenues are generated. The Size of the NCS is 2,039,951 square kilometers, which is almost three-fold of entire Norway. It was expected that till 2013 the amount of remaining reserve was 113 million Sm3 and the amount of estimated undiscovered reserve is 2940 million Sm^3. (Fact, 2014). According to the Norwegian Petroleum Directorate (2019) despite a significant reduction in oil and gas production, there will be a satisfactory increase in production from 2020 to 2023 and that might surpluses the amount of record-breaking amount ofthe the year 2004. As it is understandable form the NCS map above that there are three areas that marked with red lines on a green background, where the current petroleum production is taking place. They are in the North Sea and half of the Norwegian Sea and Barents Sea (North) to be specific and green areas are open for exploration. Grey marks with strip are the open area to explore for further petroleum discovery. Our matter of concern in this study is the area which remained blank in the middle of the Norwegian Sea and the Barents Sea, which has not yet been made open for oil companies to explore despite the huge amount of proven petroleum reserves in the region. this region is generally called the Lofoten region which calls for further investigation as to why its status quo remained intact and looks like it keeps its position even in the future.

2.2.1 The North Sea:

Initially, the large commercial oil and gas production started from the North Sea in 2070. Then gradually moved forward and expansion carried on. Currently, it is still the main source of petroleum production where most of the production comes from and around 60 fields are actively producing oil and gas. The area consists of 142,000 square kilometers. This petroleum province is divided into three parts the southern North Sea, the central North Sea, and the northern north sea. The southern North Sea is still an important petroleum province for Norway, more than 40 years after production started on Ekofisk. Ekofisk is a hub for petroleum activities in the area, and many fields are tied in to the infrastructure on Ekofisk for further transport via the Norpipe system. In between the northern North Sea and southern North sea, we have the central North Sea, which has an extensive petroleum history. Even Though some of the fields have been closed, several discoveries are being planned for development over the next few years, including the major Johan Sverdrup oil discovery. Lastly, the northern North Sea comprises the two main areas of Tampen and Oseberg/Troll. The Troll field fills a very important function for the gas supply from the Norwegian continental shelf and will be the primary source of Norwegian gas exports in this century. The troll was also the field that produced the most oil on the Norwegian shelf in 2013. When the largest oil fields cease producing oil, significant gas volumes can be produced in the blowdown and low-pressure period. (NPD, 2014)

2.2.2 The Norwegian sea:

A pressure of exploring petroleum resources in NCS has relatively been brought recently to the Norwegian sea when Draugen field came on stream in 1993. This was followed by such fields as Skarv Skuld and Hyme, which came on stream in 2013. Altogether there are 16 fields that are producing in this part of the continental shelf and it is no exception in closing economically not sound fields. One field Yttergryta was shut down in 2013(NPD, 2014). Oil from the fields in the norwegian sea is transported by tankers whereas gas is transported by pipes. According to norwegian petroleum directorate, the norewgian sea has substantial gas reserves. Mode of transportation and destination of this gas has also been specified by NPD report. Thus, produced gas from the fields is transported via the Åsgard Transport pipeline to Kårstø in Rogaland county, and via Haltenpipe to Tjeldbergodden in Møre and Romsdal county. The gas from Ormen Lange is transported via pipeline to Nyhamna and onward to Easington in the UK.

2.2.3 The Barents Sea:

Most of the Barents Sea is considered a frontier petroleum province, although there has been an exploration in the area for more than 30years. Only one field has been developed in the area, Snøhvit, which came on stream in 2007. The gas from Snøhvit is transported via pipeline to Melkøya, where it is processed and cooled into LNG, which is transported to the market using special vessels. Goliat is under development. (NPD 2014).

2.3 The Lofoten Region and its Economic Significance:

Lofoten region is a special region in NCS, where the Norwegian government prefers to keep the region away from any petroleum and related activities. Sample exploration activities made in the region have confirmed that the region is very rich in petroleum reserve. The decision made to keep the region intact is then looked absurd and would normally draw the attention of anyone who has an interest in studying the Norwegian petroleum industry. Before indulging deep into what and why logical questions, however, let us just have a clear understanding of what the region looks like so that we can form our rational base of economic analysis yet to come in the next parts. A discussion of existing economic activities of the region, which could be suspected to have a strong impact on oil company ban in the region, is preceded by a brief description of familiarizing the reader with the geographical settings of the region.

2.3.1 Lofoten Region at a Glance:

The Lofoton region as the collection of few and economically very important islands in Norwegian continental shelf consists of six counties in northern part of Norway including Vestvågøy, Gimsøy, Vestvågøy, Flakstadøy, Moskensøy, Væroy, and Røst. The following map helps easy imagination of where the region is located.

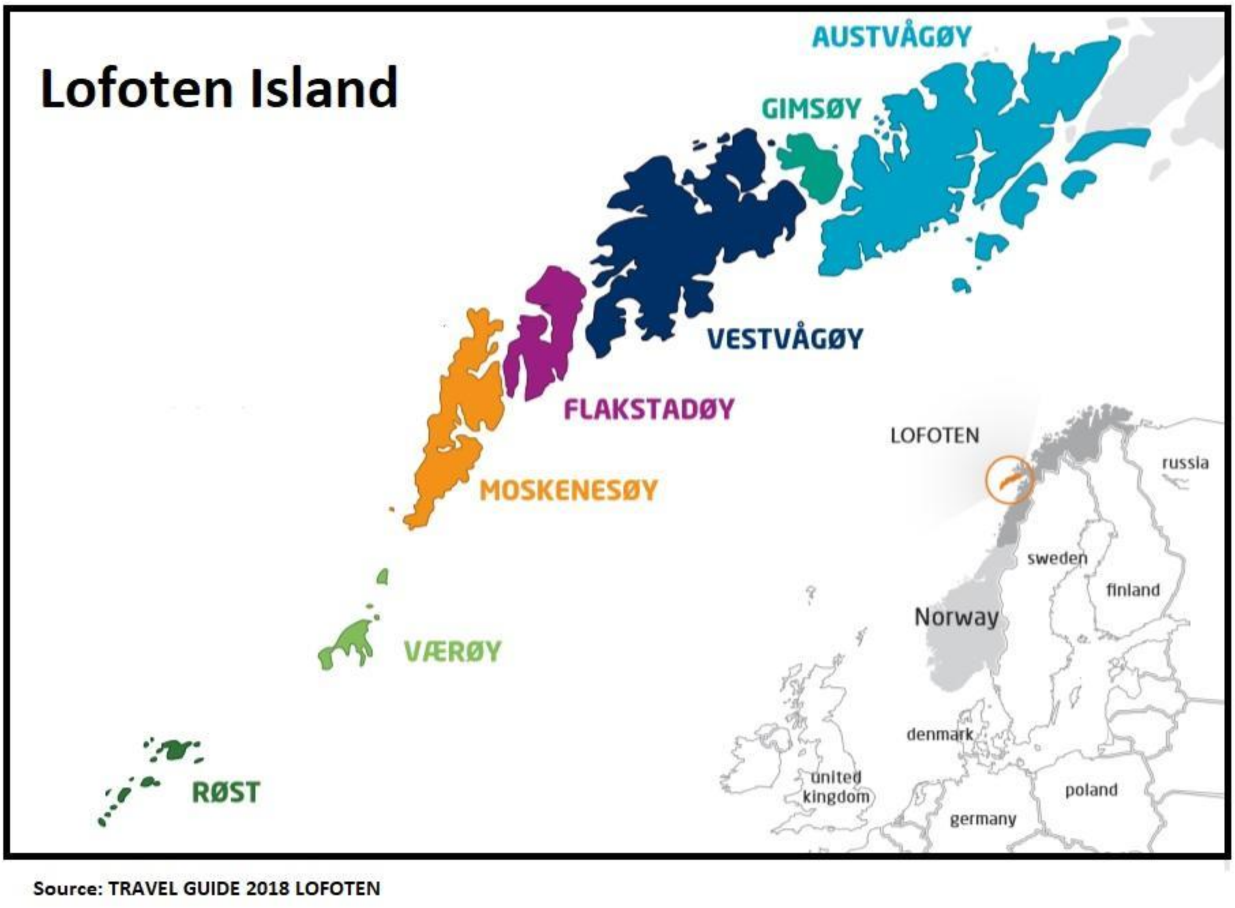


FIGURE 2: LOFOTEN REGION MAP.

Northern lights, exotic sea creatures, mesmerizing natural beauty with a lot of tourist activities like hiking, recreational fishing and many more for what Norway has been known to the world tourism industry; call can be found in one place and that is Lofoten. Even many more exotic things that only can be found in this area like the largest stock of cod fish in the world that made Lofoten one of the major fishing hubs of not only Norway but also in whole Europe. In addition, it also has a lot of tourists attract only to see the largest number of the killer whale family. So many interesting attractions have made Lofoten the top tourist destination in Norway (visitnorway, 2019). The majority of Norwegian fishing industry revenue generated from this part which makes Lofoten more and more economically important. Since it is also important in terms of biodiversity and due to environmental significance, allowing Lofoten for petroleum activities could be a devastating decision for the whole of Norway and the word environment. Before getting into this debate let's have a look on the Lofoten island at a glance. Lofoten has six municipalities and they precisely discussed below;

Vestvågøy:

With a population of 11,140 and a size of 423.1 square kilometers, Vestvågøy municipality is the largest municipality of Lofoten region. Center attraction of Lofoten tourism this municipality has the beautiful and mesmerizing scenic view that consists of steep mountains and sandy beaches. Beside considered as the geographical center of Lofoten, Vestvågøy is also enriched with marine life underneath the sea in terms of fishing. That makes it the most important fishing municipality of entire Norway. This area is also famous for Northern lights and the Midnight Sun. No wonder this area is the center of attraction for tourist who visits northern Norway. To meet a large number of tourists, demand this area has a good number of accommodation and restaurant services. People are very welcoming, and love has a traditional way of living in their modern living style (gonorway, 2019).

Røst:

The traditional municipality established in an island consists of 365 islands. Around 650 inhabitants live there, and the size of this municipality is 10.6 square kilometer. For more than 1000 years ago people started to live here and the main economic activity us fishing. More precisely, well known for dry fish export. About 35 percent dry fish of Lofoten produce here. This social fishing coast municipality has very impressive economic growth. Røst is also a tourist attraction for the midnight sun, old church and church ruins, polar night, northern lights and bird watching (gonorway, 2019).

Værøy:

The size is about 17.7 square kilometer and the population is approximately 750. Among them, around 80 percent of the workforce is in the fishing industry. Værøy has a long mountain ridge and contains a various number of activity options for tourist attraction. Like, northern lights, stockfish, bird cliff, old church, polar night, fishing and golf course (gonorway, 2019). It has different fish species that are available in different seasons and that make Værøy more attractive to any travel lover around the year (Bakos, 2009).

Moskenes:

Very famous for its scenic beauty that contains a vast mesmerizing landscape and narrow shoreline made a unique spot of Norway. Around 1200 inhabitants are living here and the area is 118.6 square kilometer. Moskenes has the highest mountain of the Western Lofoten region named Hermannsdalstinden which is 1029 meter above the sea level. Famous tourist attraction beside the northern lights and polar nights are boat trips. despite dangerous ocean, a current boat trip is one of the main adventures that attract tourists. Salmon farming and tourism are getting popular in this region in recent years (gonorway, 2019).

Flakstad:

About 1400 inhabitants live in this municipality and the size of this municipality is about 178.1 square kilometers. Most of the household are along the cost side facing the ocean. Along with fishing villages, Flakstad also has farmlands. Besides fishing, northern lights and polar nights, surprisingly it is very much well known for swimming. Because Flakstad is a warmer place compared to the other municipalities in Lofoten. Ramberg is the administrative center of Flakstad consists of a library and other urban facilities (gonorway, 2019).

Vågan (Austvågøy and Gimsøy):

Vågan municipality includes almost 9100 inhabitants and the area is 477.5 square kilometers. It also includes the Austvågøy and Gimsøy along with some other islands. As Austvågøy and Gimsøy are separately mentioned in the map of Lofoten tourism but they fall mostly under Vågan municipality. This area sometimes has the largest number of tourist concentration since Vågan is the main gateway for tourists. Several numbers of tourist attractions are present here. Including coastal steamer, Lofoten museum, Lofoten aquarium, Lofoten cathedral and many more. The largest fishing village of Lofoten can found here too (gonorway, 2019).

2.3.2 Economic Activities in Lofoten Region:

Major economic activities in the region, which are expected to fall under the direct influence of petroleum activities, are fishing and tourism sector for which the region has already won prominence. Historically the region has been known to be rich in its fish resources since the time of the Viking giving economic importance for about 1000 year. one of the most important features of the region is the fact that it is a hatching ground for different species of fish in the Barents Sea.it is also known that fishing industry stood second to oil from which Norway generates its export revenue. This old industry sector has been challenged by the giant and more valuable underground oil reserves whose value is no comparable with fish. Opening the region for oil operation has a decisive negative impact on fishing. Fish stock may be reduced due to a seismic explosion during exploration and importantly fish catching area can be limited .to the worst case however oil spill may occur which will be a cause for the total halt of the operation for sometimes and losing revenue associated with. There is a need then to investigate thoroughly if there is a mutual mechanism by which the two operate along one another.

On the other hand, the region has won wide recognition for its tourist attraction. Beautiful fjord with blue water and with combination of mountains and naturally decorated sandy beaches, the Lofoten region has a mesmerizing view that attracts thousands of tourists every year around the world (Egeland & Frøystein, 2016). Studies show that the tourism sector has been increasing in the region. It is feared that engagement of oil industry to the region might have a dampening impact on tourism revenue for oil platforms on the horizon and petroleum processing facilities on the island will have a dampening impact on the physical attraction of the region.

2.4. The Dilemma of the Lofoten Region:

Great economic importance of oil industry in Norway like other resource rich countries have a profound and major contribution in putting the nation ahead of other Scandinavian countries in a matter of two decades, which Norway used to follow them in its economic performance through its life history before 1970. The huge employment opportunity which has been created by the sector is unequivocally one of the major factors to keep the unemployment rate very low relative to other industrialized nations. The export activity which is dominated by the petroleum sector is the living witness that the petroleum industry is the backbone of the Norwegian economy. The fund mechanism developed by the far sighted and considerate Norwegians enables the country to assure itself with permanent income for the coming generation and clearly showed a need to consider far reaching impact of the decision when it comes to petroleum projects.

Thanks to the rich underground wealth, which the country is endowed on its continental shelf, a successful welfare state has been made possible partly by the virtues brought by this sector. The petroleum era begins its journey in 1969 when the Philips company discovered substantial petroleum reserve in one of its exploration fields in the North Sea, which is one part of the Norwegian continental shelf. The continental shelf that stretches from southern part of the country all along the northern part of Norway is believed to be three times larger than the main land, and has been the lifeblood of the country in economic terms, and consists of three major parts including the northern sea; the Norwegian sea ;and the Barents sea.

The process of exploration, development, and production as an integral part of the activities for petroleum industries took precedence to appear in the northern sea and continued its engagement to the Norwegian sea, and eventually made its journey to the Barents sea. It is natural and logical for oil companies to spot soft targets where they are potentially exposed to lower difficulties and lower cost with the purpose of maximizing return on their investments. It is also very common for petroleum companies to halt operation in those fields that have been proved to be no more profitable. Over the life span of 50 years of petroleum era in Norway, companies have been seen moving north in search for more oil field and in fact at the cost of assuming more risk. This movement to the northern part of Norway in search for more petroleum resource is amazingly exceptional for a special region known as Lofoten.

A class room lecture we had for our economics of energy market course, on which date we heard that Lofoton region is exceptional in the continental shelf, was no ordinary session like other sessions for it didn't pass without forming the foundation of something big- master thesis. A political decision explanation given as a reason for banning petroleum extraction in the region had further strengthened and boosted our interest to have a closer look to the region and ended up with the accomplishment of this project.

The Norwegian government has a big say in petroleum resource related issue both as an organizer of petroleum activities and as an owner of a big share of the petroleum revenue. We may not know the true intent of the politicians when they make some decisions for, they may have political reasons sometimes and/or economic reasons on another time. what we definitely know is that it will be ironic for the government to ban the area if it is proved to be economically sound when the government itself is the big beneficiary out of the petroleum extraction commencement in the region.

Leaving the rationale behind the ban on Lofoten to politicians, we preferred to approach the issue from an economic point of view and thereby provide empirical justifications in case banning or lifting the ban is supported by economic principles. A point of departure to investigate is the technical and economic feasibility of the project. So many studies show that Norway has accumulated enough skills and developed up to date technology over the span of the past fifty years to face the challenges to even worse environmental conditions further north. Exploration activities that have been done so far in this region showed that there is a huge amount of recoverable petroleum reserve that worth investment given the current market and cost conditions.

In order to really understand the government's intent behind banning based only on direct costs and benefits may result in a wrong conclusion that the decision is politically motivated. To avoid such wrong connotation to the political spectrum, we are motivated to carry out a complete economic assessment of the envisaged petroleum industry in Lofoten. Accordingly, the analysis of indirect net effect is presented right after direct net effect analysis and followed by the assessment of externality analysis. These are the three integral parts that formed our analysis in this project.

Further investigation in this research work had shown us that the conceived project has its own consequences that can be of two types, either favorable or unfavorable. The net indirect effect of such moves needs to be quantified and compared against the direct net effect of the project. The underlying fact of such analysis is that the Lofoten region is known for its rich fish resources and attractive tourism industry. A potential danger expected to this basic traditional industry of the region is the occurrence of major oil spills, which will have catastrophic consequences primarily on fishing firms in the region. The impact on the fishing sector may also extend to the Barents Sea for Lofoton region is major hatching area of different types of fish and hence providing the Barents Sea with a continuous supply of new breeds of fish stocks. On the other hand, the establishment of oil platforms on the horizon and processing facilities on the mainland near the island will unequivocally dampen the quality of recreational value of the region and to the resulting tourism revenue.

Bringing such consideration into the scene of a decision will put the region into a dilemma to either accept potential danger by allowing the project or facing the risk of losing a handful amount revenue which could otherwise have been generated. This dilemma is more apparent when one includes the external effects into the analysis.

In our investigation, we have seen the fact that there are groups of local people, who support the commencement of the project for the very reason that they can be benefited from corresponding relaxed economic activities. Equivalently, however; the idea of commencing the project in the area have faced bitter opposition and firm protests from groups of environmentalists. Furthermore; the issue has turned out to be a point of political negotiation for some political parties in the government. On the other hand, international organizations are calling for rapid reduction of fossil fuel production and eventual halting to enhance total replacement fossil fuel production with renewable sources of energy in the coming few decades. Therefore, such complex and current issue with full of dynamism involving so many dimensions, have aroused our interest; and to challenge our potential and the effectiveness of master programmed we have been through by accomplishing some productive work like this.

2.5 Oil and Gas Revenue Management in Norway:

The dilemma between the commencement of the project for its handful revenue and persisting on keeping the region intact for the safety of existing traditional industries can be highlighted even more with the understanding of how revenue management from oil and gas works. A precise explanation of resource revenue management has been given below to enable readers to understand long term impact that the oil revenue will have on the economy of many rich countries and helps readers evaluate how serious is it to ban such projects.

2.5.1 Background and Rationale for Resource Revenue Management:

Norway has implemented ad-hoc financial strategies to administer the adoption of the nation's resources, particularly about the extraction of oil and gas. These policies assist in reducing the procyclicality of the economic rule and in regulating the execution of the resource incomes towards long-term sustainability goals (Mohn, 2016). To disseminate the paybacks from oil and gas extraction income to future generations, the Norwegian administration initiated a self-governing wealth fund through which all resource incomes are placed. The bird-in-hand (BIH) rule permits only the consumption of resource incomes that have already been discharged. The policy is meant to decrease the macroeconomic effect of the resource incomes through leveling the expenditure outlook of these returns (Mohn, 2016). The disadvantage of the bird-in-hand policy is that it ignores future spending obligations associated with aging and other population dynamics.

Norwegian administration places its revenue from oil and gas extraction in a stabilization account and draws 4 % yearly from this reverse to fund its tax cuts or public expenditure. Its approach of handling resource returns is commonly regarded as a perfect example for other resource-rich nations to emulate (Landsem, 2016). Thus, Norway adopts a BIH policy even though the administration leaves adequate room for preference when appropriate. The BIH policy states that the administration allocates all hydrocarbon returns in the account and only takes out 4 % of the total amount in the previous financial period for the overall budget. The 4 % resembles the hypothetical real rate of return on the reserve (Landsem, 2016). For instance, in a period where the real growth rate equals to 2%, the progression corrected real return on the BIH reserve should be equal to 2% to make the overall proportion 4% (Landsem, 2016). On the other hand, the permanent-income hypothesis (PIH) is the standard approach of intertemporal usage behavior by private households. PIH states that variations in permanent revenue, as opposed to changes in temporary return, are the components that drive the changes in the user's consumption behavior (Mohn, 2016). The hypothesis adopts balanced forward-looking performance and indicates that a household's present consumption relies on projected future interest rates and returns. The permanent-income hypothesis is rejected in Norway concerning the management of resources from the extraction of oil and gas.

2.5.2 Critical Characteristics of the Norwegian Government Pension Fund (GPFG):

GPFG (Government Pension Fund Global) which in other words is the Oil Fund (Visbeck et al., 2017) is the first GPFG was established in 1990 with the primary aim as investing surplus revenues emanating from the Norwegian petroleum sector. Currently, it serves as the world's largest sovereign wealth fund. GPFG also holds real estate as well as fixed-income investments. Some of the historical aspect leading to the formation of GPFG include the investment and fiscal policy which have prolonged time (Mohn, 2016). GPFG has had a positive impact in a way which allows the Norwegian government to manage all assets belonging to oil and sustain oil revenues in a way which saves and creates wealth for generations to come. GPFG name was found in 2006. GPFG is not independent as it was formed to be an investment account by the Central Bank of Norway. GPFG is under the ministry of finance which has the finality in determining the investment strategy as well as ethical guidelines of the fund and all operational management by the Norges Bank

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The Norwegian fiscal policy structure ensures conserving the actual value of the fund for the welfare of upcoming generations. Also, the fiscal rule and the Fund isolates the budget from short-term changes in oil and gas incomes and leave room for the financial rule to neutralize economic recessions (Landsem, 2016). In case of considerable movements in terms of the factors which impact the operational non-oil monetary discrepancy or the value of the Fund, the modification in the consumption of petroleum income is levelled over a number of years, centered on an evaluation of the real rate of return of the reverse several years ahead (Landsem, 2016).

With the EU enlargement in 2004, the Norwegian labor market and labor migration were affected. In the same way, the Dutch disease effects were modified during the 2004-2013 boom. The Norwegian case involving resource movement majorly affected the petroleum industry. The introduction of fiscal policy limited the spending (Visbeck et al., 2017). In this case, the economic growth in Norway doubled in this period due to the boom in resources while the population increased at a rate of 2%. The resource movement was reduced by 2% due to immigration.

Part Three: Theoretical Positioning

In this part, major economic theories and concepts that are relevant in justifying our point of analysis in this research project work will be discussed. From amongst so many concepts whose relevance cannot be questioned in helping understand our point of the argument, we are limited to the most important ones including the green paradox and hoteling model; Dutch disease and the resource curse; theory of social welfare loss and the concept of opportunity cost.

3.1 The Concept of Opportunity Cost:

One of the most important concepts in the field of economics is the concept of opportunity cost. A crucial contribution of the application of principles of economics is to help decision makers identify the best alternative from amongst alternatives available. Every time an individual evaluates pros and cons of each of the alternatives available to him, and reach up on a decision by choosing one of them, the remaining alternatives will be foregone at the expense of the one that is chosen and implying that there is a cost associated with the foregone alternative. Therefore; Opportunity cost refers to the forgone alternative or a benefit that is given up when a business, an individual, or an investor chooses one plan over the other (Kurzban, 2013). Norway as a decision maker has different economic activities that it can major to generate income. However, gas and oil production seems to be the best alternative for the country for it enables the nation to achieve a major success to the extent of becoming one of the leading oil and gas producers in Europe. The activities forgone as the country emphasizes in gas and oil production are now the opportunity costs.

On the other hand, the country may reduce its concern on gas and oil production and direct its resources towards Fishery and Tourism. Fish has been taking the second position in the rank of the most important exports since the years 2012. It has been accounting for about 6% of the exports (Modalsli, 2018). Also, tourism is a potential sector in Norway. In 2017, it accounted for about 6.6% of the country's exports (Xie & Tveterås, 2018). Increased focus in the sectors can result in a significant increase in the export volume and the GDP. This implies that oil and gas production is an alternative that dampens the country's effort from benefiting more from fishery and tourism, which are potential sectors. The increase in exports and hence the GDP that would be realized if the country focused on Fishery and Tourism instead of gas production is the opportunity cost of the country's emphasis on oil and gas production.

3.2 Green Paradox and Hotelling Model:

German economist Hans-Werner Sinn first introduced the concept of green paradox. Precisely, when new climate policy is imposed or the impose of new climate policy in future is announced for reducing environmental degradation, fossil fuel producers, foster their production to maximize their benefit and increase the GHG emissions.

As a matter of fact, the whole concept of global warming experiences a complete unintended boost instead of reduction. This mechanism can be well explained by the hotelling model. As per figure-3 when there is the imposing of a carbon tax in 2030 is announced in 2020. The fossil fuel producers increase the extraction to capitalize the time period before the carbon tax is being imposed which is by 2030. Whereas, this excess production increases the supply of fossil fuels in the market and reduces the price. Extraction and availability of cheaper fossil fuel rise the oil consumption hence foster pollution as well as global warming. This is known as “Green Paradox”. This situation, however, carries on until the time of environmental policies comes into motion 2030 when the carbon tax is imposed, the extraction quantity and the market price come to the natural states (Mohn, 2017).

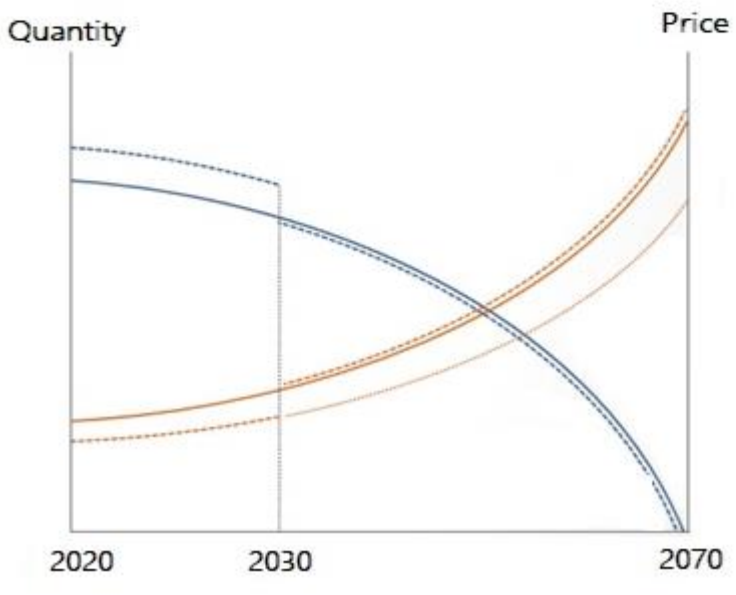

FIGURE 3:HOTELLING MODEL

3.3 Dutch Disease and the Resource Curse:

The resource curse is a common phenomenon for any resource rich country. It refers to the problem of unexpected slower economic development and bad governance of resource rich countries. Countries with large endowment of natural resources tend to have worse economic development compared to the non-resource rich countries (Humphreys, Sach, & Stiglitz, 2007). Even though these countries supposed to experience economic flourishment derived from the natural resource abundance, they, however, most of the cases failed to do so. Michael L. Ross (2018) mentioned that since the problem arises due to petroleum abundance, so calling it mineral course would be more accurate. Because, not other natural resources like forests, fresh water or fertile farmlands are responsible for this problem. He also mentioned that oil producing countries across the Middle East, Asia, Africa, and Latin America are less wealthy and less democratic than they were in three decades ago. Humphreys, Sach, & Stiglitz (2007) in their book chapter on resources curse have described every detail about resource curse. According to them, scarcity of natural resources has not caused any critical obstacle to economic success. Paradoxically, countries with lower natural resources have shown promising development through their export-oriented manufacturing industry. Resource rich countries are mostly suffering from inequality, civil war, gender discrimination, autocratic government and corruption, and this problem are what ignited with the discovery and extraction of natural resources. Unlike other poorly performed resource rich countries Norway, Canada, and Great Britain have shown how oil revenue can be enjoyed with a well-planned fiscal policy and diversified economy (Ross, 2012). There is two major significance in natural resources. Firstly, natural resources don’t need production. It is extracted and independent from any other economic activities. The government of resource rich country less likely need the involvement of its public or any industrial sector to make any kind of decision in this regard. Secondly, the natural resources mostly oil and natural gas are non-renewable and from an economic perspective, it is more like an asset rather than a source of income. These two attributes give rise to some unethical profit seeking entities like corrupt government officials sector, politicians and corporations and thus lead to adverse economic and political consequences of natural wealth. (Humphreys, Sach, & Stiglitz, 2007)

Dutch disease refers to an economic downturn into the manufacturing and other industry of a country due to a favorable economic boom caused in another sector like the discovery of large natural resources, price appreciation of an exportable commodity internationally and due to sustainable aid or capital inflow (Brahmbhatt, Canuto, & Vostroknutova, 2010). The report by the World Bank also mentioned three different sectors that are subject to the problem of dutch disease, the natural resource sector, the non-resource tradable sector, and non-tradable sector based on Corden and Neary (1982) research. According to them, natural resource sector consists of all kind of naturally available resources of a country, which are extracted and exported to other nations and non-resource tradable sector consists of mainly manufacturing and agricultural outputs of a country, which are exported into other countries but not naturally available. The common point in this regard is that the price of these two sectors is determined by the world market. Whereas, the price for the non-tradable sector is internally determined in the domestic economy (Brahmbhatt, Canuto, & Vostroknutova, 2010).

On the other hand, the spending effect and resource management effects are the two effects caused by Dutch disease. Spending effect arises when a booming natural resources sector increases the domestic income and purchasing capacity it also pushes the aggregate demand of the economy. In addition, wages also go up. Demand for non-tradable services goes up so do their prices and outputs. Profit margin becomes narrower for the non-resource tradable sector like manufacturing and agriculture, thus lose the competitive edge in the world market. As it was mentioned before that prices are not controllable for non-resource tradable items and currency deflation is also responsible for losing the competitive edge. Despite its short run positive economic growth, natural resource abundant countries, however, have significant negative growth in the long run (Brahmbhatt, Canuto, & Vostroknutova, 2010). The resource management come into motion when natural resource abounded sector draws most of the capital and labor inflow from the other sectors and that causes the price of the output of the non-tradable sector to increase proportionately.

3.4 Social Welfare Loss Theory:

In economics, social welfare loss or deadweight loss is an outcome of market inefficiency. It is an inefficiency in allocating economic resources to society. According to Investopedia; "*When consumers do not feel the price of a good or service is justified when compared to the perceived utility, they are less likely to purchase the item. With the reduced level of trade, the allocation of resources may become inefficient, which can lead to a reduction in overall welfare within a society.*"

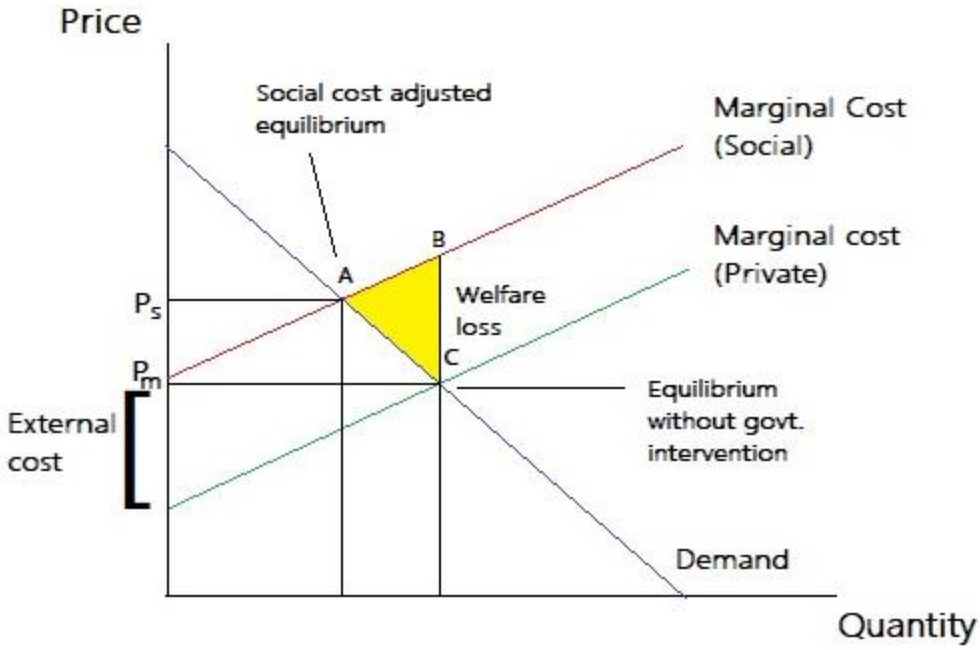

FIGURE 4: SOCIAL WELFARE LOSS.

When we calculate the social marginal cost and the social marginal benefits, the cost incurred by the society due to the negative externality usually not included. That is why society cannot reach the optimum equilibrium point until these external costs are adjusted. If we look at the figure above that the social marginal costs curve is far above from the private marginal cost. Because the social marginal cost curve also has taken externalities into account and reflects the optimal equilibrium point. And the triangle ABC is the DWL or welfare loss to society.

3.5 Tragedy of the Commons-The Theory:

The tragedy of the commons is a problem in the field of economics in which economic agents try to maximally gain from a given resource (Mansbridge, 2010). The term " tragedy of the commons" is used to describe a situation in a shared resource system where individual users acting independently according to their own-self-interest contrary to the common good of all users by depleting or spoiling the resource through their collective action(Garrett Hardin,1968). The theory of the tragedy of the commons takes a grazing common ground for farmers breeding cows and tries to assert the risk of over grazing which will eventually result in decreased milk production. for such resources, the two available mechanisms of allocation are either to let private ownership where one person owns the field and decides on grazing activity or to have common ownership where access is free and unrestricted so that productivity of milk depends up on the total activity.

Since commons are limited in their supply, the behavior of its users may risk its depletion and coordination has been a challenge in the management of the commons. For example, as the demand increases to higher levels than supply, every consumer who buys an additional unit of the commodity in question directly harms those who no longer get the commodity. Another example is evident in the depletion of non-renewable resources. These resources cannot be renewed and reused again (Akpomuvie & Orhioghene, 2011). Therefore, whenever a unit of the renewable resource is depleted, other individuals no longer have access to it. The depletion, therefore, harms them directly. It is thus a tragedy of common.

One of the potential challenges that the world is facing due to oil and gas production has been linked to the emissions of greenhouse gases. Researches show that climate change and the consumption of oil are interrelated. When oil products are burned, they produce such gases as nitrogen and carbon which form greenhouse gases when they get to the atmosphere. These greenhouse gases deplete the ozone layer thus creating a way for the penetration of the electromagnetic waves which cause cancer. Also, they prevent the heat emitted from the atmosphere escaping to the atmosphere (Kahan, et al., 2011). This leads to global warming which is responsible for the melting of icebergs and rising sea levels resulting in heavy rains in the coastal regions and flooding. This phenomenon then has been a major issue in attracting the attention of major players of the world into energy sector scene, whereby stakeholders are trying to respond to the requirement of bringing the solution through coordinated efforts.

Environmentalists, nations and concerned organizations have been putting forward their plans as a solution which goes to the extent of influencing economic performance level of world nations. An apparent carbon release quota set for countries and IEAs scenarios which outlines carbon release limits to enable 2 degree warming temperature in the coming few decades can be quoted as an example for the practicality of the coordinated effort being made.
A theoretical concept of the tragedy of the commons is presented and discussed for the relevance of the theory to the project is manifested by the fact that Norway like other countries needs to adhere to the requirements of IEA by significantly reducing or else halting its oil and gas production as per the specifications set in the sustainable development scenario.

3.6 Cost-Benefit Analysis (CBA):

Mishan and Quah (2007) described cost-benefit analysis as a systematic approach and analytical process to evaluate the desirability of a project or program by comparing its benefits and costs. They also mentioned in their book that CBA is to identify the worthiness of a project at its optimal scale by comparing with the constraints. Likewise, Hjort (2016) also described CBA as a systematic approach for estimating the short- term and long-term consequences by measuring all costs and all possible profit or benefits of an investment project proposal. Both qualitative and quantitative factors are taken into account in cost benefit analysis and also sometimes known as Benefit and Cost Analysis.

As it was mentioned that CBA considered all possible costs and benefits. Therefore, CBA considers indirect costs and externalities of a project as well. Afterward, CBA attempts to quantify all possible costs and benefits of a project by assigning a monetary value for each benefit and costs. The theoretical foundation of CBA was well portrayed by Pearce, Atkinson, & Mourato (2006) based on the measurement of human wellbeing. Benefits refer to the increased human wellbeing (utility) whereas the decrease in human wellbeing considered as a cost. Under the CBA ideology, a project or policy will be accepted only if its social benefits exceed the social cost or when WTA > WTP.

Under aggregation rules CBA is segregated into two parts, one is measuring cost and benefits based on willingness to pay for possible benefits (WTP) and willingness to accept compensation (WTA) for possible losses. This study is a very widely used technique around the world, especially among the economist. The second rule is aggregation over time which requires discounting also known as Net Present Value or NPV. The future benefits and costs are adjusted more precisely discounted by using the inflation rate to get the present value of the future benefits and costs of a project. More importantly, a combination of logical sequential steps is required. There is uncertainty attached to costs and benefits and that is why risk (probabilistic outcome) and uncertainties (when no probabilities are known) also require to take into account. In addition, it is also important that distributional incidents of cost and benefits are identified and included in the calculation. (Pearce, Atkinson, & Mourato, 2006).

NPV rules widely used by firms for managerial decision making. So far, NPV rules are the most accurate and reliable rule among several others and mostly accepted. Even it is evident from Graham and Harvey (2001) study that based on their field survey about 75 percent of the firms used the NPV method to make investment decisions. Which is far more than what it was in 1977, where only 10 percent of firms used the NPV (Berk & DeMarzo, 2014). Thus, the prominence and popularity of the NPV method are understandable in the business word.

Part Four: Literature Reviews

There is a common understanding among major public that successful resource rich countries have been enjoying vast economic successes and bringing admirable welfare to their people. It is also the undeniable fact the reverse is the case for those that failed to manage their blessings successfully. What major public may be ignorant of is the fact that even those model countries sighted for their successful operation of petroleum resources have had a tempting situation when it comes to such resources. In this part, we have attempted to present potential adverse consequences, which could otherwise be obscured at the cost of too much emphasis given to the benefits arising out of petroleum. we need to remind once again that full economic assessment requires every possible pros and cons attached to a project at hand needs to be taken into account as much as possible. Therefore; some related literature done in the past with this regard have been selected andpresented in the order that the reader can have a better understanding as he or she keeps reading, and come across the idea of net indirect benefit in the later parts of this project.

4.1 Oil Spill Valuation Study:

As resource rich countries reap the fruits of the extraction of their natural resources, they themselves and\or others with or with no direct relation with the commercialization of these resources have been seen to suffer the adverse consequences when things went wrong. Disastrous events had been encountered both from oil spills by the passing by ships and oil rupture at the extraction site resulting in the different magnitude of losses. Case studies of previous oil spill incidents like Deepwater Horizon, Prestige oil spill, and Exxon Valdez oil spill are some of the major incidents that teach resource rich countries and companies engaging in oil extraction to assess potential risk of their operation ; and enable them develop preventive and control measures to either mitigate potential risks or avoid totally such miss happenings from occurring . These major developments are so far the immense source of information and data to estimate the magnitude of the possible future damages and its effect on the economy due to oil spills. In this part, we would like to mention some of the key world class incidents, and some norwegians experiences in-order to identify cost implications associated with the possible oil spill, as we believed presenting them is worth mentioning.

4.1.1 Exxon Valdez Oil Spill Case:

Exxon Valdez oil spill is the second largest man-made environmental degradation due to the accidental oil spill in the history of the United States. On March 24, 1989, after it left from Valdez, Alaska experienced a terrible accident caused by collisions with an iceberg in the Prince William Sound. Before the Deep-Water Horizon oil spill, Exxon Valdez was the direst oil spill accident in terms of the magnitude of the oil spill of US history and caused catastrophic damage to the environment and economy (Wikipedia, 2019). Largest habitat of salmon was affected and that also affected the commercial salmon fishing as well as other fishing. It was one of the costliest cleanups and damage recovery disasters as per several studies (Paine, et al., 1996; CARSON, et al., 2003). The estimated passive use value losses in USD 2.8 billion as the lower bound. Where the State of Alaska and U.S government accused Exxon authority for natural resource damages and for injuries and as a compensation claimed USD 1 billion for these losses. At the same time, Exxon company spent USD 2 billion damage recovery and other oil spill responses. One study by Cohen (1995) illustrated some interesting facts. It was obvious that his study found that a number of fish stock reduced after the oil spill and during some period fishing restriction was imposed into the contaminated areas. Mostly the local small fisheries were affected mostly, and Exxon involved the local labor force into the recovery works where the local income was increased by three-fold after the immediate impact. According to him, the social cost to state fishing industry was USD 108.1 million and because of after effect in 1990, during the following year of the oil spill, the social cost was USD 47.0 million.

4.1.2 Prestige Oil Spill Case:

Prestige a 26-year-old tanker carrying 77,000 metric tons (MT) of heavy low-quality oil sunk about 222 km away from Galicia, Spain. A terrible storm caused the accident on November 13, 2002, and sunk on 19th of the same month. It had been affecting the coast of Portugal, France and mostly Spain for 4 months by spilling more than 60,000 MT of oil (Loureiro, Ribas, Lopez, & Ojea, 2006). It was one of the devastating oil spills ever recorded in history. Total loss for the year 2002 to 2004 was expected to be EURO 770.58 million. Beside commercial losses from fishing and tourism industries, it was also responsible for severe damage to the environment and animal life. Accumulated loss due to Prestige oil spill in the affected area was estimated to be EURO 152.26 million to the fishing and fishing related industry, to the tourism sector it was EURO 110.55 million and the loss incurred by the animal life was EURO 25.12

million and cleanup and other cost were EURO 509.42 million. However, quantifying these losses especially the environmental and indirect cost is complicated and tough to be accurate. Nevertheless, Loureiro et. al (2005) came up with the most acceptable possible estimation in their research. Which could be a very useful method while estimating any future oil spill contingency studies discuss in the later part.

4.1.3 Deepwater Horizon Oil Spill Case:

Deepwater horizon was an offshore oil extraction platform established in the Gulf of Mexico by British Petroleum (BP), that exploded in 20th April 2010 due to methane [1] bubble. It was the devastating oil spill accident in the history of the US, caused a loss of 11 lives and several injuries. Beside the financial losses to the petroleum company BP and the US government, It also causes several damages to the environment and ecosystem. A total of USD 36.9 billion amount of loss was incurred to be precise (Smith, Smith, & Ashcroft, 2011). Even though the drilling rig was recovered by 15th of July 2010, however, the losses within these 3 months was a wakeup call for the world to realize the magnitude of the risk of damage associated with the petroleum rig. Approximately, 206 million gallons of oil were spilled causing several areas to close for fishing, caused vital damages to the marine life and so on (Alvarez, Larkin, Whitehead, & Haab, 2014).

This major oil spills adversely affected the tourism sector along with the fishing industry. According to Smith et. al (2011) commercial fishing and tourism industries incurred an estimated loss of USD 4.36 billion and USD 3.80 billion respectively. However, their study also found that the exaggerated behavior of public media about this oil spill caused more damage to the tourism industry. This is also some important inputs for our study when we consider the probable effect of the oil spill in the Lofoten area.

4.2 Petroleum Extraction and Potential Consequences:

There have been heated debates, which have been going on among the concerned Norwegian stakeholders about whether to go for Lofoten gas and oil or not. Those arguing against such project enumerate several adverse impacts the region could be exposed to; had it been allowed. whereas, those who argue for the commencement of the project in the region presents a number of facts which could possibly eradicate fears of those against the project by emphasizing the need to have a quick decision before the giant under the ground turned out to be worthless within a few decades. Some of these seemingly positive and seemingly negative points of argument are discussed here.

4.2.1 Lofoten Petroleum Extraction and Employment:

Apart from a significant amount of revenue generated through sales of oil and gas, there are several positive impacts if the Lofoten region is opened for petroleum activities. One of them is employment. A study by the Ministry of Oil and Energy (2012) stated that there is a 95% probability for 76 million Sm3 oil reserve and 5% probability of 370 million Sm3 oil. This will open around 400 to 1100 new employment opportunities regionally and 800 to 2300 nationally (Misund & Olsen, 2013). Historical facts and empirical researches show that oil and gas extraction activity create employment not only in its own industry but also results in sizable employment opportunity in other service and supplier sectors that will eventually be established to serve the oil and gas industry.

However, there is a need to recognize the fact that employment in traditional industries would face difficult situation primarily from wage pressures exerted by oil industries as this challenge their competitiveness. Therefore; it is obvious that part of social benefit generated through direct employment can be offset through resulting wage pressure in other traditional industries employment

4.2.2 Petroleum Extraction Impact on the Fishing Industry:

Norway is the world's third largest fish exporter in terms of export value, (Hjermann, et al., 2007). The condition portraits a very healthy economic condition and development of these two sectors simultaneously going and growing. However, it doesn’t seem the same when we talk about the Lofoten region. The harsh truth is that growing of one of these sectors might cause the other sector to deteriorate. This is one of the most unpleasant dilemmas that Norway has been facing for several years. Lofoten region which is located in Barent sea area contains one of the most valuable fish stocks of the Atlantic Ocean (Hjermann, et al., 2007) and the fishery has been carried on for 1000 years during the Viking era (Misund & Olsen, 2013). There is an abundant stock of cod and other commercially important fishes like NEA haddock, saithe, etc. It is expected to be disturbed or reduce due to petroleum activities. If we consider the amount of export value for oil and gas, and fisheries which are NOK 46 billion and NOK 8.4 billion in 2019 respectively (SSB, 2019). It is easily realizable that how significant is the

oil and gas resources for the economy compared to fish in terms of monetary value. Nevertheless, in this case, the direct revenue is considered; indirect and external costs are yet to be taken into account.
In addition to exerting wage pressure through resource movements, oil extraction activity poses major challenges that can be analyzed under two cases. The first case is the one whereby seismic operation and the release of wastes into the sea during drilling which is expected to force fish to flee the region. Mohn (2018) clearly pointed out the possible negative effects may derive from crowding out effect, income and activity losses and the loss of competitiveness of other businesses due to wage pressures from the petroleum sector.

Secondly, if the platform oil spills happen beside environmental damages these two industries will also face a period of a business halt in that area, which will cause financial losses. It is certain from the other literature (Loureiro, Ribas, Lopez, & Ojea, 2006) (Loureiro & Loomis, 2012) that the fishing will be paused for a certain time period until the oil and oil residuals are removed. However, the length of the time period that how long it will remain close for fishing depends upon the quantity of oil spilled, weather condition, and quality of oil, etc. If the oil spills occur during the spring, early summer or late winter then there is a definite chance that free-floating eggs, larvae, and less-mobile juveniles will be damaged. That will affect the fishing population in the immediate future. However, adult and large fish may swim away from the oil spill area (Misund & Olsen, 2013) At the same time, the possibility that the seabed will be contaminated due to oil spills and exploration is high

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For example, in 2010 alone the total value of catch from the Lofoten area was NOK 1303.685 million (Høgi, 2010). Not only that oil spills can have a significant impact on fish stock (Hjermann, et al., 2007) oil spill can hamper the fishing industry even after the fishing is resumed. As a matter of fact, besides the commercial value of fish, the fishing related industries like canning, cold storage, transportation, and other fish processing companies will also be affected. Even some of them could be gone forever, especially the small and medium companies. Risk of these losses also needs to be analyzed and calculated precisely.

4.2.3 Petroleum Extraction and Its Impact on Tourism Industry:

The Lofoten region mostly comes into the spotlight for its enriched fishing industry and petroleum exploration. Tourism which is a growing industry in the Lofoten region had comparatively less covered in the studies. Beautiful fjord with blue water and with combination of mountains and naturally decorated sandy beaches, the Lofoten region has a mesmerizing view that attracts thousands of tourists every year around the world (Egeland & Frøystein, 2016).

Petroleum extraction and settlement and of course oil spills have a serious adverse effect on the tourism industry both locally and nationally. Besides, harming its natural beauty; oil settlement might also cause visual pollution. Therefore, it is important to include the income generated from tourism industry while calculating benefit and cost. On the contrast, it is also evident that an oil settlement development might boost the tourism sector like hotel and restaurant business for a certain period of time. Some studies also found out that fishing and tourism industries are somehow correlated in the sense that if the fishing industry is affected due to petroleum extraction activities, it will also affect the tourism industry. However, the amount of magnitude of these effects is yet to be measured. While it is evident that, the number of inhabitants in the Lofoten region is decreasing as well as fishing revenue, Younger people are moving out from that area into the big cities and the remaining inhabitants are getting older (Bakos, 2009).

The number of inhabitants is decreasing as we can observe from the figure above. Where in 1975 it was around 26,500 people and by 2008 it reduced to almost 23,500 people. At the same time, the tourism sector in the Lofoten region is increasing. Therefore, tourism is very crucial for the region to keep the financial circle alive as well as social development.

Petroleum exploration might reduce the number of recreational tourism but on the other hand, it might also boost the official visits and stay. Lofoten tourism could be another important hub for official visits by the petroleum industry people and thus foster the hotel, restaurant, transportation, and other recreation activities.

4.2.4 Petroleum Extraction and its Environmental Impact:

Beside the fishing and tourism industry, there is a high possibility that oil exploration will also be responsible for environmental degradation. The Lofoten region has unique environmental attributes and amusing animal life which is very important for the ecosystem. During the spawning time largest cod fish come to this area, especially to Vestfjorden (Egeland & Frøystein, 2016) and due to environmental constraint cod and herring have very short but intensive spawning period. These fish stocks are economically and ecologically very crucial for both Norway and the Barents Sea. The Lofoten-Barents Sea (LBS) is an open Arcto-boreal shelf-sea and it has a narrow continental shelf along the Norwegian coast up to Lofoten and the average depth of the sea is 230 meters (Hjermann, et al., 2007). Importance of this area is not limited to Norway; this area is the main food source for entire Europe. Besides that, it has enriched the coral collection and the area has the largest deep-sea coral reefs in the world. In addition, a big amount of plankton also grows in this area (Egeland & Frøystein, 2016). Nature of this region is a big attraction for tourist around the world. People come to visit the Lofoten region to enjoy its iconic natural beauty. Few of the main attractions is bird-watch and whale-watch. Probably Lofoten has the healthiest and strongest population of killer whales in the world said by Hanne Strager, a marine biologist (2019) in a documentary on oil free Lofoten. It was also said that the natural wonder of Lofoten is unparalleled and very unique. Therefore, the environmentalist and others want to keep the Lofoten area oil free. Because, if the oil extraction happens then nature will not be that same. Pollution both environmental and visual, hampering the natural life cycle of wildlife and disruption of ecosystem might cause irreversible damage. That is why all the observer bodies to the government of Norway like Norwegian Polar Institute, the Climate, and Pollution Agency and directors of Natural Management and Fisheries argues against opening Lofoten region for offshore oil and gas exploration (Misund & Olsen, 2013). Polar region ecosystem is very simple and thereby very much vulnerable to environmental degradation for a number of valuable species. It is evident that the dramatic reduction of capelin fish stock in the 1980s; cause a significant impact on the capelin’s prey, zooplankton, cod, herp seals and shrimp population in Lofoten marine life. (Hjermann, et al., 2007). On the other hand, oil reserve in the continental shelf is reducing, even though it is harmful to the environment to explore new oil and gas sources, but it is also necessary for economic wellbeing. Even though accidental oil spill is very low, however, future is unpredictable, and accidents happen; and if accidental oil spills happen this area is going to suffer dire consequences than another area of the world (Misund & Olsen, 2013).

4.3 World Energy Outlook and its Implication on Oil Producing Countries:

The World Energy Outlook is an examination of the change in the global energy system. It finds that the global energy sector is undergoing major transformations. For instance, there is an expansion of the renewables and growth in electrification. Also, countries are cutting their oil production and natural gas markets' globalization to focus on alternatives that save the environment (Birol, 2019). It is the responsibility of every country to make the transition so as to save the environment from pollutants which mainly come from the energy sector. Developed countries have the upper hand in the pollution due to their huge industrialization compared to the developing nations. They are expected to make major shifts to electrification and expansion of renewables so as to significantly reduce environmental degradation. IEA as an international organization and forefront body concerned with environmental safety has consistently outlined alternative ways as to how nations should behave in satisfying their energy needs based up on some assumptions. The resulting scenarios have a major characteristic in putting, for example, a time limit for the achievement of the objectives of the united nation. Some of the most important is sustainable development scenario, the current policy scenario, and the new policy scenario.

4.3.1 Sustainable Development Scenario:

Sustainable development is aimed at achieving a 2-degree carbon emission by the year 2070. However, most of the countries are not working towards the target. Norway, for example, is a developed country expected to achieve a huge cut in oil production and increase electrification. However, it is focusing on oil and gas production which are instead harming the environment.

4.3.2 Current Policy Scenario:

Currently, governments are required to have more impetus in designing policies capable of helping in achieving sustainable development (International Energy Agency, 2017). For instance, in the absence of the impetus from the Norwegian government, the existing policies may lead to more supply of energy but increased depletion of resources and destruction of land that would be used as a shelter for wild animals by commencing petroleum extraction in the lofoten region.

4.3.3 New Policy Scenario:

The government should now come up with measures aimed at reducing its exploitation of land for fossil fuels. The Norwegian government is committed to climate policy and environmental sustainability. The last review of the energy policies of Norway by IEA (International Energy

Agency) shows that the country sustainably manages its hydrocarbon revenues and resources (Global Engagement, 2019).

4.4 Pollution from Petroleum Activities in Norwegian Continental Shelf:

Since the time of oil discovery and extraction of oil in the Norwegian continental shelf marine life and environment has been affected badly. Even initially at the beginning of offshore oil extraction the magnitude of the pollution was not completely realized. Before the late 1980s, it was known that only 1 km radius of an offshore platform was affected due to petroleum extraction activities. however, later based on realistic data it was found out that the effect is under-realized and actual effect was almost 10 times more that covers around 3 km radius area, not 1 km (GRAY, BAKKE, BECK, & NILSSEN, 1999). It was wake up call for the Norwegian government and a new policy has come into motion in 1993 and intentional discharge of oil-based drilling and cutting has been restricted since then. Pollution doesn't stop there. It was also found that biological effects are much more than it was predicted by Environmental Impact Analysis (EIA) reports. Several numbers of benthic invertebrates around the oil platform (rig) was reduced in number due to oil concentration and the presence of this effect was found up to 10 km area of the drilling discharge point.

TABLE 1: ACCIDENTAL OIL DISCHARGES IN NCS

Year	Discharge quantity (m3)	Description
1977	12700	Largest discharge on NCS happened on Ekofisk Bravo in connection with a weeklong blowout.
1992	946	Oil discharge on Statfjord field as a follow of a safety valve on a hose to a loading buoy, was leave in open position.
2003	750	Discharge of crude oil from a break in the connection to the sea-bottom installation on Draugen field.
2005	350	Oil discharge on Norne field when a manual safety valve in the system for produced water stood in wrong position.
2007	4400	Oil discharge from a under water hose who break off in connection with oil loading from Statfjord A to a tanker.

Source: SFT 2009 cited in (Bakos, 2009)

There are some other accidental oil spills happened occasionally. The table above shows the accidental oil discharges up to 2009. Even though the probability of big accidental oil spills is very low, yet not unexpected. In a normal scenario, some small-scale accidental and unintentional oil and chemical spills are more or less eminent.

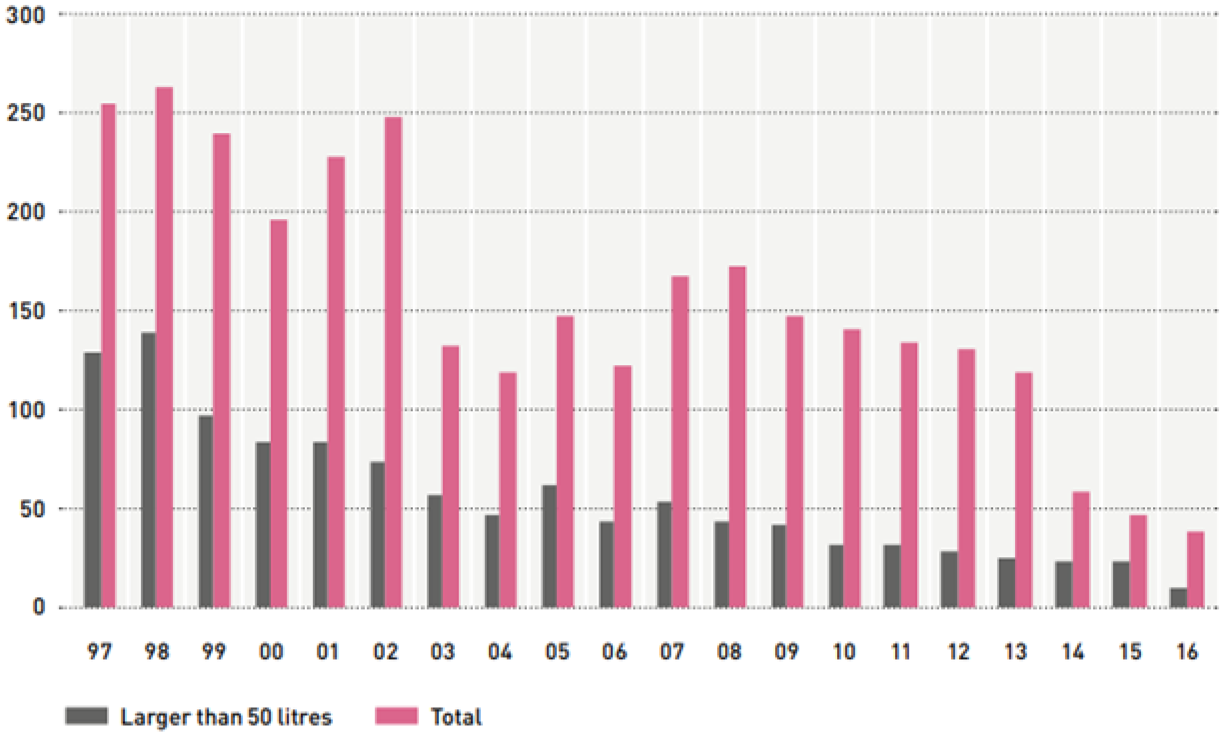


FIGURE 5: UNINTENTIONAL OIL SPILLS FROM 1997 TO 2016 IN LITTERS

Source: (Norsk Ojle & Gass, 2017)

The direct CO2 emission is almost stagnated to just below 400 tonnes annually since 2009. 82% of this CO2 is caused by the turbines (as per the year 2016). (Norsk Ojle & Gass, 2017)

4.5 Summary of Literatures:

This is the summary of the literature that this study has covered during its journey specially to identify and understand different effects (direct/indirect/external) . Especially different costs/benefit identification and their valuation techniques and methods with a combination of location and output are presented into this part (Appendix-XVI). The summary table of literature has 7 columns. The first column contains the literature title and the author's name with the time of the publication (year). The second column says the location of the study and the third column contains what is the research is about. The fourth column contains the core conceptual base for our study. That explains what kind of cost or benefit that each research is talking about. As per our research context, the different costs and benefits are segregated into

3 different types of effects indirect, direct and external cost or benefits. Under the cost benefit assumption of this study, we developed and assigned what kind of costs or benefit that particular research is discussing about. This part is one of the foundation parts for our study to understand the associated costs and benefit for petroleum extraction, cleanup, environmental or opportunity costs for petroleum development. The fifth column about alludes to that what kind of research techniques, model and methods is/are used in the literature. Followed by the data collection source and techniques that are used, this in the sixth column of the table. Last but not least, the table has finished with the column that contains the results of the researches. This table in appendix XVII contains the summaries of 50 researches and the reports, books that we covered are not included in this summary table.

Alongside the author and topic, the first column illustrates the timeline of researches that when the researches were conducted and how recent the outputs are. Recent studies contain the most updated findings and cover the previously done literature into their studies. Our study mostly contains the recent studies and by recent, we indicate any studies after 2005 to present. Among 50 studies 43 studies are conducted in between 2006 to 2019. 1 study from 1995 and before, total 6 studies from 1996 to 2000 and 2001 to 2010, 14, 18 and 12 studies are from 2006 to 2010, 2011 to 2015 and 2016 to present respectively.

Locating which is the second column of this table contains vital information about the location where the study conducted. Among several, most of the researches that we have taken are conducted in Norway. More specifically, the Norwegian continental shelf (NCS), Lofoten and Lofoten region, the Arctic area, the Barents Sea and the North Sea. The underpinning concept of our study is centered to Lofoten area in Norway, therefore mostly our literatures are on Norway.7 studies are conducted on the overall oil spill and related consequences around the world. Mostly these studies are done based on a pool of secondary database collected from different sources. Apart from, that vital oil spill accidents like Prestige (Spain), Deepwater Horizon (USA), Exxon Mobil (Canada) influence us to investigate the aftermath of this accident into the respective countries. Remaining locations are Finland, Germany, the UK and Austria, Russia, Greenland (Denmark), Nigeria, Scotland, and China. Some studies are not any country specific rather than more specific on collaborative region like G20 countries (Visbeck , et al., 2017), Scandinavian countries (Larsen, 2006), 8 (Lindholt, The tug-of-war between resource depletion and technological change in the global oil industry 1981 - 2009, 2013) or 7 (Bernarda & Vielleb , 2003) specific regions around the world and the Arctic region.

In the third column, we tried to illustrate the study objectives or what these studies are looking for and the fourth column contains the what kind of effect these studies are talking about.

Intended for better understanding we discussed these two columns combinedly. Any cost related to petroleum production, development and extraction is classified as a direct effect (Cost or Benefit), any costs or benefits related with tourism, fishing, petroleum supply sector industry and clean-up cost falls under indirect effect and lastly social, environmental and ecosystem damages considered as an externality in this study. Some literature analyzed the combined effect of all costs to mostly understand the overall effect of petroleum activities or accidental oil spills like oil spill damages, the probable damages to the overall economy, environment and other relative industries are discussed by Loureiro, Ribas, Lopez, & Ojea (2006), Helle, Ahtiainen, Luoma, Hänninen, & Kuikka (2015), Alló & Loureiro (2013), Smith, Smith, & Ashcroft (2011).

Mohn (2016) discussed highly dependent petroleum income based fiscal policy and its effect on the economy directly and indirectly. A comparative study on Norwegian economic growth conducted by Larsen (2006) with the other Scandinavian countries and tried to pinpoint the reason behind the 2002 economic slowdown of Norway. A straightforward analysis of economic and environmental losses is covered by Smith, Smith, & Ashcroft (2011) and another study on complete possibilities and prediction on the future of Petroleum exploration of Arctic zone has done by Harsem, Eide, & Heen (2011). Five literatures contain direct effect studies (Misund & Olsen, 2013) (Mohn, 2019) (Rashed, 2013), (Lindholt, 2013) (Mohn, 2016). The findings and analysis of Mohn (2019) are a notable worthy to talk about. A clear and precise but very deeply analysis of probable direct income from petroleum activities in the Lofoten region has been portrayed in his article. As a matter of fact, Mohn's model and findings have become our foundation for direct costs analysis.

After the direct effect, assessing the indirect effect is an essential part of our study. Oil and gas extraction could have a significant effect on other businesses in the locality. Mostly negative effect on fishing (Hjermann, et al., 2007), (Carroll, et al., 2018), (Høgi, 2010), (Gil, Blanco, & Rodriguez, 2006) and tourism (Bajada , 2016) (Butler & Fennell , 1994) (Amundsen, 2012) (Ritchie, Crotts, Zehrer, & Volsky, 2013) (Xie & Tveterås , 2018). Probability of oil spill (Liu & Wirtz, 2009), (GRAY, BAKKE, BECK, & NILSSEN, 1999), (Bakke, Klungsøyr, & Sanni, 2013) or crowding out (Mohn, 2019) effect derives from the petroleum sector will be responsible for this negative effets. In order to, assessing the probable oil spill cleanup costs we studied previous literature to understand how it has been quantified and understood so far. Scope of damages and loss of income due to accidental oil spill has thoroughly reviewed in the literature part (Konotovas, Psaraftis, & Ventikos, 2010), (Montewka, Weckström, & Kujala, 2013), (Prendergast & Gschwend, 2014), (Hauge, et al., 2014), (Ventikos, Vergetis, Psaraftis, & Triantafyllou, 2004) (Zhang, Han, & Shi, 2015).

Lastly, one of the critical issues was to defining and quantifying externality. Quantifying environmental losses, social losses and other ecosystem losses needed to be explained into monitory value. However, a combination of different studies on WTP (Liu, Wirtz, Kannen, & Kraft, 2009), (Egeland & Frøystein , 2016) and other factors (Peters & Hertwich, 2006), (GRAY, BAKKE, BECK, & NILSSEN, 1999), (Kristoffersen & Dale, 2014) (Bakke, Klungsøyr, & Sanni, 2013) (Loureiro & Loomis, 2012), (Olsgard & Gray , 1995), (Bernarda & Vielleb , 2003), (Telleza, Nirmalakhandanb, & Torresdeyc, 2002), (Visbeck , et al., 2017), (BENEDICT , 2011) (Werf & Maria, 2012), (Hasle, Kjellén, & Haugerud, 2009), (O'Brien, Eriksen, Sygna, & Naess, 2006), (Kaltenborn, Linnell, Thomassen, & Lindhjem, 2017), (Dale, 2016) helped us to understand how vast could be the effect of external effect.

Even though, we extracted the information mostly from those articles which have at least one of the three effects (direct/indirect/external). The methodological approach and data analysis models, however, it varies from article to article. Analysis of indirect effect for example fishing from oil spills analyzed both scientifically and economically and their techniques and valuation will differ that is almost certain. A study conducted by Hjermann, et al. (2007) on oil spill effect on fish population likewise Kaltenborn, Linnell, Thomassen, & Lindhjem (2017) done the same with a similar methodological approach which is simulation models. Whereas, Gil, Blanco, & Rodriguez (2006) identified the short-term fishing and tourism losses from the Prestige oil spill incident by using economics modeling and managed to present the losses into monitory values. About 26 times the quantitative methods are used (economics and statistics), around 18 times analysis was based on different qualitative analysis like case study, review of literature and others. Around 5 times purely scientific methods are implemented; some of them used lab based chemical experiments and some of them mechanical techniques. However, in these kinds of scientific researches we utilized here are mostly to the get related understanding not for overall understanding (Carroll, et al., 2018) (Bakke, Klungsøyr, & Sanni, 2013) (Hjermann, et al., 2007) (Telleza, Nirmalakhandanb, & Torresdeyc, 2002). Among these 50 articles, different data collection techniques are used. Primary data, secondary data and classified review of literature considered as the techniques for data collection. Some of the research used a combination of 2 or 3 data collection techniques together. Mostly, survey and on field experiments are the source of primary data collection. On the other hand, secondary data are the major source for most of the literature that we have covered. Primary data, secondary data, and review of literature were used as data collection in literature summary for 16, 25 and 12 times respectively. As some studies used a different combination, therefore, we avoid the number of studies, we used how many times these techniques are used instead.

The result column is a vital column for our study where we found most of our measurement units and monetary values. Some studies came-up with associated cost in oil and gas exploration, both real (Loureiro, Ribas, Lopez, & Ojea, 2006) (Konotovas, Psaraftis, & Ventikos, 2010) (Liu & Wirtz, 2009) (Smith, Smith, & Ashcroft, 2011) (Alló & Loureiro, 2013) and hypothetical (Montewka, Weckström, & Kujala, 2013) (Helle, Ahtiainen, Luoma, Hänninen, & Kuikka, 2015) oil spill recovery cost and cost to economy incurred due to the spills. Since there are few small and medium oil spills but there has been an absence of any significant major spill incident in the Lofoten or the Arctic area, we, therefore, had to study the other oil spill cases and how they have measured and analyzed the oil spill incidents. There are some other studies on oil spill analysis and possible annihilation on the economy, related industries, social and environmental damages that significantly contributed to the course of our study. Some noteworthy mentions are the average per tonne cleanup cost identified by Konotovas, Psaraftis, & Ventikos (2010) is USD 1639 with a marginal cleanup cost of USD 23085/tonne and the marginal total cost is USD 33,425/tonne. Montewka, Weckström, & Kujala (2013) and Helle, Ahtiainen, Luoma, Hänninen, & Kuikka (2015) have conducted research on probable oil clean-up costs and effective oil cleanup mechanism. First research shown from 5000 to 15000 tonne oil cleanup cost is in between EUR 12.1 million to EUR 144 million and the second one by Helle *et.al.* illustrate how installing new Automated Alarm System (AAS) can be significantly cost effective and estimated cleanup cost EUR 15 million/30km2. Both these studies were conducted on the Gulf of Finland, as a Scandinavian country Finland up to some extent resembles similar Scandinavian atmospheric characteristics like Norway. That is why these two studies were also important for the study for in depth understanding of oil spill aftermath in the Nordic region. while calculating the environmental cost and social cost WTP (Willingness to Pay) is one of the widely used indicators. A study by Liu, Wirtz, Kannen, & Kraft (2009) on the North Sea coast in Germany came up with a yearly WTP of EUR 29.1 per household for the probable accidental oil spill. similarly, another study by Loureiro & Loomis (2013) came up with WTP for the damage caused by Prestige oil spill on three countries Spain, UK and Austria those were EUR 124.3, EUR 80.87 and EUR 89.08 respectively.

Part 5: Methodological Approach:

The core objective of this study is to try to answer a question "should Lofoten area be open for oil and gas for petroleum extraction?", and to contribute our perspective of analysis to stakeholders, who may take facts presented here as a starting point for further analysis or decision making. The objective also extends for academicians, who are interested in working on the same topic by creating a groundwork and setting point of direction to them so that they are able to produce a better-quality output with less ease. We decided to answer this question based on the cost-benefit analysis of petroleum exploration, development, and extraction activity. We attempted to find the optimal cost and benefit of the project in the Lofoten area if it is open for petroleum activities. In doing so we included the direct, indirect and external benefit and cost into the study. As it is mentioned before that our model is to find the net direct, net indirect and net external effect to come into a conclusion about oil and gas exploration decision in Lofoten. Even though there have been some empirical researches done with respect to oil and gas exploration in this region, no one of them, however, is done in such a way that policy makers can rely solely on to make the decision for they don't depict total economic or social surplus and/or total economic or social loss. Consequently, then attempts have been made to come up with a complete picture by taking into account most relevant variables as much as possible in this study. Here then, one may observe different methods that are implemented to analyze and interpret data with the ambition of coming up with the desired big picture of the project. All the models and methods that are applied are designed in order that they can help our basic tool: a cost-benefit analysis.

5.1 Data Types and Collection:

Almost all of our data, which are used in this study, are secondary data. The sources of these data range from such sources as previous studies to reports, from books to online statistic bank and other secondary sources. For the sake of simplicity three major inputs have formed the core of our analysis, including analysis of related literature; framing base of our study with theory, and cost benefit analysis. Relevant theories and concepts have been given priority and outlined in part three with the intention of forming theoretical positioning that will support our analysis and creating a logical flow of what we are trying to address. Secondly, some of the most important literature with great significance to assert our position have been presented and discussed in part four.it is known that all of this information and endeavors made to analyze them may not easily be understood unless they are quantified. Part five then is entirely devoted to quantifying all or most of the variables by assigning them equivalent monetary values as a result of which the net benefit of the project can be determined.

The conceptual framework is based on such theories as opportunity cost, green paradox, the Dutch disease, and the resource curse, social welfare theory, tragedy of the commons and cost benefit analysis. Importance of opportunity cost concept lies in the fact that this project is going to recommend some actions as a result of which some others are still ignored together with their potential benefits. A decision to go for Lofoten may increase oil and gas supply which results in price reduction as per the law of demand which will result in more consumption and more pollution and necessitates the inclusion of the concept of green paradox. opening Lofoten has an impact of resource movement from traditional industry and creating pressure on their competitiveness and analyzing this fact calls for the concept of Dutch disease and the resource curse. social welfare theory is included with an intention of describing the result of the whole project that could either be positive or negative from a societal point of view. the need to adhere to international agreements and taking measures to meet common objectives of reducing carbon emissions and thereby keep the environment (common good) necessitates a discussion of the concept of the tragedy of the commons. Finally, forming a conceptual framework for our basic tool of analysis(cost-benefit analysis)in this part have really been made indispensable before we really apply it in the actual part of the analysis.

Literature reviews consist of some basic literature works, that are believed to have great significance in helping the understanding and facilitating of the analysis part, have been carefully selected and presented. Research works, which are deemed to have relevance to our point of argument include the process of oil and gas extraction; oil and gas revenue management; oil spill valuation studies; petroleum extraction and potential consequences; world energy out-look; and petroleum activity pollution in Norwegian continental shelf. Fundamentally, the process of petroleum extraction includes petroleum exploration, filed development and production and operation activities. having a clear understanding of these activities paves the way to deal with the corresponding costs on which the analysis of direct effect is constructed. This is followed by the oil and gas revenue management in Norway, where the importance of the mechanism of the global pension fund has been highlighted and its functionality has been discussed. An analysis of Oil spill valuation studies has been done with the purpose of depicting the importance of including the analysis of such potential risks in the project that we have at hand.one of the main aim of this project is to show that petroleum extraction has ripple effects beyond direct costs that some may spot them easily. Such indirect effects are then listed and discussed under petroleum extraction and potential consequences part. energy outlook is discussed with the purpose of emphasizing one of the scenarios of the outlook towards whose achievement that our analysis is done and influence the result of the analysis. as we are trying to follow a holistic approach; attempts have been made to include the external effects of the project in the analysis.to this effect, some real experiences countered on the Norwegian continental shelf have been discussed.

For the analysis part, relevant data have been gathered from different sources such as previous research works, SSB, NPD, and other related documents and reports. These data are processed, squeezed and presented under three major sub-parts of the analysis. Direct effect part tries to provide important information with respect to project cost and the resulting revenue. A part which follows is devoted to the explanation of the indirect effect of the project where it outlines both positive and negative impacts of the project and tried to come up with the net impact. The third part assesses limited data, which are in fact informative enough to show the externality of the project had it been commenced.

5.2 Data Analysis Techniques:

From amongst widely applicable project profitability assessment technique, we heavily depend up on the extensive application of NPV method. In principle, projects are considered to be worthy as long as their NPV turns out to be positive. Here is how the model works. Being a project with a long span of life it is characterized by subsequent cash outflows and cash inflows. cash outflows every year are then deducted from corresponding cash inflows in the same year to come up with the profit margin of that year. These net cash flows for subsequent years over the life of a project are each discounted to 2020 at which year a decision to open lofoten for oil and gas industries is expected to be made. The whole process involves NPV calculation by taking into account direct cost and benefit, indirect cost and benefit as well as external costs and benefits if there are any.

5.2.1 Direct Cost-Benefit Analysis:

A point of departure for our cost-benefit analysis is the valuation of direct costs and corresponding revenues. Following the model applied by mohn in his (2019) article estimated total costs and corresponding production levels have been taken into account. Accordingly cost element is the summation of exploration, development, and operation costs, represented by subsequent annual expenditures that extends to 2070. By taking projected production level into account, we have calculated corresponding resulting projected revenue and consideration to oil and gas price changes have been taken into account. More precisely the model includes the possible cost of exploration, development and extraction costs of oil and gas for the time period of 50 years, from 2021 to 2070. The adjustment in the price of both oil and gas have been made in order to reflect the most recent market values and an exchange rate of NOK to USD has been updated. So, the price of oil is set USD 65 (NOK 585 bbl.), and the price for gas has been set USD 2/boe, and the adjusted exchange rate USD/NOK has been 9. Subsequently, the projected net cash flows are identified by deducting the cost from the revenue for each year up to 2070 and then the projected net cash flows (CF) are discounted with 3% discount rate, which is also the Global Pension Fund rate of return. When discounted cash flows (DCF) are added, the net present value (NPV) was found which is considered as a net direct effect.

Dynamism to one or more of the variables used in the calculation to come up with this NPV has been taken into account as a result of which the model was made a little bit more relaxed and represent real life situation. sensitivity analysis has been done by introducing changes to price, reserve estimates, and costs of the project with an intention to reflect uncertainties. This enabled us to analyze at least four scenarios. A clearing ground for sensitivity analysis was made when we developed our reference scenario with a basic assumption of the major variables .then after by introducing assumed percentage changes in the price, we have analyzed how sensitive NPV is in what we called scenario I. keeping cost element constant we made resource estimate to react to changes in price and analyzed how sensitive NPV is to such considerations in scenario II. Following the same procedure further, in our scenario III, we let the cost variable to react to price changes and have determined how much sensitive NPV is when our consideration disregards any change in the resource volume. A more comprehensive scenario is scenario IV where both cost and reserve estimates are made to respond to price changes and represent more logical assumption to which again we have obtained different sensitivity of NPV under such consideration.

5.2.2 Indirect Cost- Benefit Analysis:

In addition to direct benefits and costs associated with this sort of projects, there are tremendous ripple effects, which can better be considered as Indirect benefit or cost. Our main analysis tried to take into account these ripple effects as much as possible where the positive indirect contribution of the project must have been offset by the negative indirect consequences. For this reason, the positive indirect contribution has been represented by the amount of indirect employment the projects are expected to create, and by the revenues generated from the expected supply sectors. this is to say that possible indirect benefit is the benefit that the Norwegian economy will enjoy from flourishment of the petroleum supply sector industry. Due to new additional oil and gas production, exploration and extraction a handful of petroleum related supply industry will be established and the benefit from this sector will add into the Norwegian economy by generating new revenue and opening new employment. on the other hand, an offsetting indirect move is apparent when existing companies lose their competitiveness due to increased wage, and traditional industries like fishing and tourism are at risk of losing their income due to the possible danger of oil spill. The level of damage when happens is so intense that may go to the extent of inflicting damage to the national level for the Barents Sea is the major source for Norwegian fishing industry which will become vulnerable to oil spill accidents. Actually, Major oil spill could lead to irreversible damage to the fish stock and thus to the fishing industry. Moreover, this artificial industrial settlement will demotivate the tourists.

The technique we followed here was the one that was implemented by Loureiro, Ribas, Lopez, & Ojea (2006) for estimating the admissible cost of Prestige oil spill. We found this technique is the closest to the realistic valuation of losses from any oil spill. We have also taken the last 10 years fishing revenue was used to identify the growth rate. Sum up the average and divided by a number of years.

$$fishing\ Sector\ Growth\ Rate\ (GR) = \frac{\sum percentage\ change\ in\ fish\ catch\ of\ each\ year}{Number\ of\ years}$$

As we know that Lofoten is the number one tourist attraction of Norway. Simultaneously, the reduction of fishing and tourism will also hamper the fishing and tourism supply sector industries. For example, cold storage, transportation, fish processing factories, etc. (Loureiro, Ribas, Lopez, & Ojea, 2006). Even though the fishing ban depends upon the quality and quantity of oil spills, weather and geographical location, but we are considering a hypothetical oil spill situation where the possibility of the oil spill is 100 percent (Mohn, 2018). In this regard, we are also considering a 100 percent ban on fishing and 100 percent tourism reduction up to 2070. This is the maximum loss that can be incurred in case of a worst-case scenario.

There after we added the cleanup costs. In the second part of this calculation, the indirect costs are deducted from the indirect benefits and the net indirect benefits are discounted with 3 percent discount rate for the 50 years span and added to get the net indirect effect. Present value (PV) formula for 50 years is shown in equation 5.3.

$$PV = \frac{FV_{Cf\ 2020}}{(1+r)^{t_0}} + \frac{FV_{Cf\ 2021}}{(1+r)^{t_1}} + \cdots \frac{FV_{Cf\ 2070}}{(1+r)^{t_{50}}}$$

5.2.3 External Benefit-Cost Valuation:

The third part of the total economic assessment approach we followed involves the analysis of external costs and benefits in relation to this project. as far as this project is concerned these external effects tend to be generally negative for potential risks of operation have the tendency of damaging bird life, fish stock, and dampening recreational qualities of the region. It is then really apparent that valuation of external costs is more complex than the two previous valuation we have discussed due to lack of market value for some of the subject of valuation. Hence following previous research approaches, we used survey-based methods to reveal the willingness to pay for the quality of nature, environmental goods, and recreational values.

5.3 Limitations of the Study:

There are several limitations comes into this kind of study while looking for an optimal cost benefit analysis. Yet, we tried to come up with a realistic result as much as possible. Firstly, we are considering a hypothetical oil spill study for the study which less likely to occur. By doing this we are calculating the net effect for the worst-case scenario. At the same time, the accurate data amount is nearly impossible, but we tried to be as realistic as possible while quantifying the associated environmental costs.

Lack of data on fishing and tourism supply industry in the Lofoten area was hard to get and needed more in depth data collection like going to the Lofoten areas and collect data form the municipalities. Which was not possible for us for a master thesis due to time and resource constraints.

Part 6: Analysis and Findings

6.1 Cost-Benefit Analysis:

Besides explaining some of the basic theoretical concepts and describing relevant past empirical studies that form the cornerstones of this project, here comes the lifeblood of the whole endeavor that this project is trying to address: a cost-benefit analysis. Policy makers, unlike individual investors, are not pre much occupied by simple calculation of cost and revenue associated directly with the deemed project. They are instead very much ambitious about total welfare gain in relation to a project at hand (petroleum extraction in Lofoten in our case) while evaluating a project. This is because a full economic assessment will have to include the net effects from indirect effects that include ripple effects of either related industry development and employment in the region; and /or crowd-out of traditional industries (Mohn,2019). Mohn further argues that the external economic effect will also have to be considered in a full evaluation of the economics of arctic oil and gas activities for the relevant decision criterion for an invitation of oil and gas activities in the region should be based on the sum of these three valuation elements.

Accordingly; we have organized our analysis in such a way that easy understanding prevails. Analysis of direct costs and revenue takes precedence and forms basis for the coming analysis, which will soon be followed by the discussion of indirect net benefit. The remaining third part is entirely devoted to the analysis of the external effect of the project in case the project is commenced. The general analysis can be modelled by the following diagram depicted in figure 6

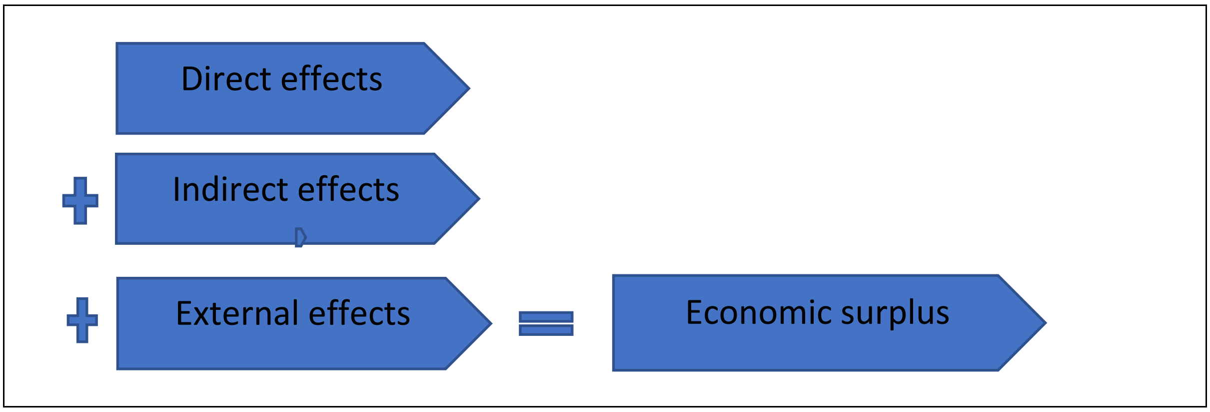


FIGURE 6: COST-BENEFIT MODEL

6.2 Direct Effect Analysis:

Direct costs and revenue analysis requires such basic information as the amount of recoverable oil and gas, cost of extraction per unit of measurement, proportion of oil and gas content, commencement period of the project, life of the project, cash flow per period, selling price as well as the discount rate. Assumptions on different variables will extensively be used to take an element of risk and uncertainty into account that helps to develop possible scenarios, which will later govern the whole analysis of this part and the subsequent parts. Discounting is a basic tool which will widely be used to bring subsequent cash follows towards its base year(2020) monetary value and thereby determine NPV of the project.

In the second part of the analysis, the indirect effect of the project will be analyzed. Since the Lofoten region is rich in fish resources, birds and animal life as well as the tourism industry, it necessitates consideration of the potential impact that petroleum extraction could have on these industries. Acquisition of updated related data and a careful quantification of these resources are an important step in the determination of net indirect impact in the analysis. Careful valuation of these factors is highly recommended as some of them even lack market value. The effect here is either positive or negative and hence there is a need to take only net effects as much as possible into our analysis. In addition to that, a probable oil spill cleanup cost has also been a part of indirect effect analysis. We stablished and analyze a hypothetical oil spill situation and estimated the cleanup cost for the oil spill.

The last part of the analysis tries to analyze the worst-case scenario where external environmental damage is quantified and carbon is taxed at a presumably reasonable price; and finally, it provides directions for decision under such considerations.

6.1.1. Estimation of Petroleum Resources in Lofoten Region:

A point of departure in our analysis is the estimation of the underlying resources in the region of consideration. Practically seismic exploration as well geological survey coupled with some exploration drilling is used to estimate petroleum reserves.

The Barents Sea is often viewed as an essential fish nursery and is a cold-water system that is vulnerable to oil pollution. The region has symbolic value for Norway which includes its popularity as a tourist spot, for fishing and recreation (Henderson & Loe, 2014). The Lofoten region has minimal exploration activities since it is located at sea, specifically near the Lofoten islands on the Norwegian coast, despite the extensive oil reserves. One major issue was the impact of environmental damage which was considered during the exploration phase (Norwegian Petroleum Directorate, 2014). Questions have also arisen if the exploration activities can still occur with the current attitudes about climate change and policies. Furthermore, lack of accurate maps on offshore resources demanding climate, stakeholder management, and technology requirements are some of the variables that have led to the rising risk and cost of gas and oil exploration. The climate and energy policies are also not supportive of large-scale oil and gas operations happening in the Lofoten region. There is a national consensus of 58% who believe that drilling should not occur (Mohn, 2019). Despite so many such seemingly non inviting conditions, Oil was first discovered in the 1980s through drilling expeditions, and it took several years for its development.

The Norwegian Petroleum Directorate's assessment is shown in figure 1, with the estimated valuation of the resources followed by a P05 (high) and P95 (low) estimate due to the uncertainty. The Lofoten region has oil and gas reserves amounting to 1.3 billion barrels, with oil accounting for 64%. The assessment is that there is a 95% likelihood that the resource will be over 480 M boe and a 5% likelihood that the resource is over 2.3 bn boe.

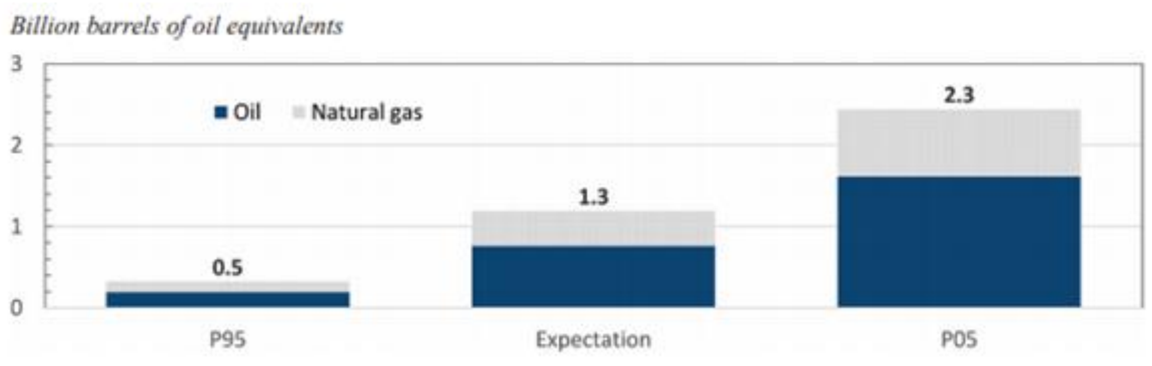


FIGURE 7: AMOUNT OF OIL AND GAS RESOURCES IN THE LOFOTEN BASED ON PROBABILITY.

The above figure shows the amount of oil and gas resources in the Lofoten region after a handful of exploration activities were made. The graph shows that there is at least 480 million barrels of oil and gas and at most 2.3 billion barrels of oil and gas in the region. The region is rich both in oil and gas and it is estimated that 64% is oil and the remaining 36 % is gas. It follows then there is 95 percent probability that 307 millions of barrels of oil can be found mixed with 173 millions of barrels of gas, and there is a 5% probability that about 1.5 bn boe of oil mixed with 800 million boe of gas can be extracted from this region. The reference scenario, which takes uncertainties into account; however, expects 1.3 bn of boe whose 832 millions of barrels are expected to be oil and the remaining 468 million boe are estimated to be gas.

6.1.2 Valuation of Oil and Gas Resources in Lofoten Region:

Dynamism in market variables is a major playmaker in the valuation of tradable goods like petroleum products. Thus, different past empirical researches depict different values for oil and gas reserves in Lofoten area valuation needs to reflect the contemporary market price of the goods. It is not surprising then if one comes across different values for the same level of resource beneath the surface of the earth while studying the same place at a different period of time.

Even though inflation can basically be one of the main differentiating factors, the price factor is prominent to bring about some gaps over the years. We, as researchers of this paperwork, have used price level, which exists during the month within which this part of this paper was written. Accordingly, a price of $65(NOK 585) per barrel of oil, a price of $2(NOK 18) per Scm, as well as an exchange rate of USD to NOK (9 NOK) was used. Using the cash flow table in Appendix-I the discounted cash flow shows NPV of NOK 179 bn as per the reference scenario.

6.1.3 Sensitivity Analysis:

Sensitivity analysis is a study of how different values of independent variables can affect the value of dependent variables under a given set of assumptions, where our dependent variable is the amount of oil production and independent variables are all set of inputs that can affect level of output including the amount of resource, cost of production as well as selling price. Sensitivity analysis can also be considered as *"what if"* type of study where we try to predict the outcome under different values of inputs within a range for uncertainty and risk is part and parcel of any business in today's dynamic world.

The uncertainty or risk in oil and gas projects span a range of value drivers and no ex ante risk analysis can possibly address them all (Mohn 2019). Mohn further argues that the risks involved in oil and gas exploration and extraction may be sorted in four broad groups: underground risk, technological risk, risks related to markets and prices, and risks related to politics and policies. Any assessment of uncertainty and risk should, therefore, ensure representation of these broader groups of risk factors. By creating sets of assumptions, we will end up with alternative levels of profit as measured by net present value, while quantifying uncertainties in major input variables. Introducing changes in one or more of such independent factor as resource size (underground risk), cost (technology), oil and gas prices (markets and prices), and discount rates and progress delay (policies and politics), enables us to develop some possible scenarios so that viability of the project can be assessed from different angles.

6.1.4. Development and Analysis of Scenarios:

Scenarios are possible future alternatives that are likely to happen and hence require a point of reference against which possible other alternatives can be compared and analyzed. Our point of departure then is our reference scenario with basic assumptions to value drivers summarized in table 2.

TABLE 2: REFERENCE SCENARIO INPUT

Variables	Unit	Value	Scenario Adjusted Values	
			33%	-33%
Recoverable resources:	Bn boe	1271		
Oil	Bn bbl	813		
Gas	Bn boe	458		
Oil Price (real)	USD/bbl	65		
	NOK/bbl	585		
Gas price real	NOK/sm3	2		
	USD/MMBtu	5.86		
	USD/fat oe	32.54		
	NOK/boe	292.9		
Exchange rate	NOK/USD	9		
Discount rate	Percent	3%		

The above table consists of important inputs, which together with appendix I, enables the calculation of NPV. According to the reference scenario, the amount of resource is estimated to be 1.271 bn boe with 64% (813mb) are estimated to be oil and the remaining 36% (458mboe) are estimated to be natural gas. current selling price is NOK585 (USD 65) per barrel of oil in real terms and natural gas price is assumed to be NOK2/Sm^3 on an average, which in fact equals NOK 292.9/boe using standard conversion techniques. An exchange rate of USD 9 reflects the rate on which this analysis was done. using a time period of 50 years and an interest rate of 3%, all cash flows are discounted to the year 2020 to come up with NPV of NOK 179 bn.

Discounted cash flows and then resulting NPV figure, with detailed calculation is depicted in the Appendix. I and is summarized in the following table.

TABLE 3: REFERENCE SCENARIO OUTPUT

Gross revenue (NOK bn)			Total cost (NOK bn)				Net cash flow	Discounted cash flow @3%(NPV)
Oil	Gas	Total	Exploration	development	operation	total		
476	136	610	51	55	61	167	443	179

According to the above table, revenue sources are separated between oil and gas for their relative quantities must be multiplied by different price levels per unit of measurement. Given basic assumptions, this results in generating a total revenue that worth NOK 610 bn throughout the life of the project. This huge amount of wealth becomes real only at the expense of the corresponding cost of exploration, development, and operation shown in the above table. These three costs sum up to NOK 167 bn. The difference between the cash inflow and cash outflow is estimated to be NOK 443 bn as indicated under net cash flow column. Following the assumption of 3% discounting rate, we can end up with an NPV of NOK 179 bn of the giant underground in the Lofoten region.

Having this reference scenario into account, we will analyze the sensitivities of NPV by introducing changes in the value drivers. Changes in selling price are subject to market conditions, whereas changes in cost is a function of input price and technological breakthrough. changes in resource size reflect basically geological risk and in fact has high relation with the amount of fund available for exploration, development, and operation. These changes allow us to analyze four scenarios under which NPV of direct costs are assessed. The analysis will further be done by taking the indirect costs and benefits as well as external cost into account in the subsequent section of this chapter.

6.1.4.1: Scenario I - Oil and Gas Price Sensitivity Analysis:

Following previous empirical works in this first scenario of our analysis, we introduced a +/- 33% change in price while keeping other factors constant. It is true that temporary price increase will increase sales volume but here permanent price change is assumed, and this cannot be thought without having an impact on resource volume. In practice, expectations for extracted oil and gas volume (i.e, reserve estimates) will hardly be independent of oil and gas prices. For the sake of our analysis; however, we assumed price changes as if it is occurring independently, and basic assumptions are summarized in the following table.

TABLE 4: PRICE SENSITIVITY SCENARIO INPUT

Price Sensitivity Scenario-1				
Variables	Unit	Value	Scenario Adjusted	
			0%	**0%**
Recoverable resources:	Bn boe	1271		
Oil	Bn bbl	813		
Gas	Bn boe	458		
Oil Price (real)	Change		**33%**	**-33%**
	USD/bbl	65	86.45	43.55
	NOK/bbl	585	778.05	391.95
Gas price real	NOK/sm3	2.000	2.660	1.340
	USD/MMBtu	5.860	7.794	3.926
	USD/fat oe	32.540	43.278	21.802
	NOK/boe	292.900	389.557	196.243
Exchange rate	NOK/USD	9		
Discount rate	Percent	3%		

The above table summarizes some of the important inputs required to calculate NPV under our scenario-I. Accordingly, changes are only introduced to the selling price of oil and gas by about +/-33% while resource volumes and costs remain unchanged. using a time period of 50 years and an interest rate of 3%, all cash flows are discounted to the year 2020 to come up with NPV that ranges between of NOK 87 bn to NOK 270 bn.

Discounted cash flows and the resulting NPV figure, with detailed calculation, is depicted in Appendix II and III and is summarized in the following output table.

TABLE 5: PRICE SENSITIVE SCENARIO OUTPUT

Gross revenue NOK bn			Total cost NOK bn				Total net cash flow	Discounted net cash flow
oil	gas	total	exploration	development	operation	total		
633	178	811	51	55	61	167	646	270
319	90	409	51	55	61	167	243	87

The above table summarizes the sensitivity of NPV to price changes. Figures from Appendix II show how sensitive NPV is when the price is increased by 33% which results in 91bn more Norwegian kroner before price shift. Whereas results from Appendix III shows that a 33% fall in price is expected to result in approximately 92 bn less Norwegian kroner and resulting in NPV NOK 87bn.

6.1.4.2. Scenario-II: Resource Reserve Sensitivity Analysis:

In this second scenario, we have introduced a reaction of the resource size to a permanent change in the price of oil and gas. Therefore, the sensitivity of NPV will be a more logical reflection of the changes in independent value driver price. High oil and gas prices will normally be associated with higher levels of exploration activity and larger discoveries, more profitable development projects, and more activity to extend field lives, and increase the recovery rates of producing fields(Mohn 2019). The assumptions for the sensitivity analysis under this scenario is summarized in input table 6.

TABLE 6:RESOURCE RESERVE

SERVE SENSITIVITY SCENARIO INPUT

Reserve Sensitivity Scenario-2				
Variables	Unit	Value	Scenario Adjusted	
			16.5%	**-16.5%**
Recoverable resources:	Bn boe	1271	1481	1061
Oil	Bn bbl	813	947	679
Gas	Bn boe	458	534	382
Oil Price (real)	**Change**		**33%**	**-33%**
	USD/bbl	65	86.45	43.55
	NOK/bbl	585	778.05	391.95
Gas price real	NOK/sm3	2	2.66	1.34
	USD/MMBtu	5.86	7.79	3.93
	USD/fat oe	32.54	43.28	21.80
	NOK/boe	292.9	389.56	196.24
Exchange rate	NOK/USD	9		
Discount rate	Percent	3%		

The above table consists of primary inputs to be used in the net present value calculation. All of these inputs except one are the same inputs we used in scenario I. The logical reaction pattern of resource volume to price shocks has been considered here. Mohn argues that the response in total oil and gas reserves to one percent change in product prices is assumed to be 0.5 percent. To this effect then we introduced the amount of reserve estimate shock of 16.5% for a corresponding 33% change in the permanent price of oil and gas. The detailed NPV calculation is depicted in Appendix IV and Appendix V. The result of this calculation is presented and described in the following output table.

TABLE 7: RESOURCE RESERVE SENSITIVITY SCENARIO OUTPUT.

Gross revenue NOK bn			Total cost NOK bn				Total net cash flow	Discounted net cash flow
oil	gas	total	exploration	development	operation	total		
738	108	843	59	64	71	194	650	276
266	75	341	42	46	51	139	203	73

The above output table shows a summary of Appendix VI where an increase in the price of the resource encourages more exploration and results in more reserve estimates, as well a summary of Appendix V whereby oil and gas price reduction results in the dampening effort to explore more. The first row with figures gives a summary of the calculation for relative increases in the value drivers that could lead to the generation of NPV of 276 bn Norwegian kroner whereas, the second row summarizes calculation of NPV when the relative decrease is expected which could result in NPV of NOK 73bn.

6.1.4.3. Scenario III -Cost Sensitivity Analysis:

Here once again it is assumed that only one of the value drivers, which in fact is a cost, is assumed to respond to changes in price levels. This is to say that for a permanent shock in the price of oil and gas, only corresponding costs are assumed to respond while reserve estimates are expected not to change. Even though it is most common that price changes are automatically followed by changes in cost level or vice versa in real time and results in increased exploration effort, for the sake of validity of the sensitivity of NPV the following assumptions are in hold.

TABLE 8: COST SENSITIVITY SCENARIO INPUT

Cost Sensitivity Scenario-3				
Variables	Unit	Value	Scenario Adjusted	
Recoverable resources:	Bn boe	1271		
Oil	Bn bbl	813		
Gas	Bn boe	458		
Oil Price (real)	**Change**		**33%**	**-33%**
	USD/bbl	65	86.45	43.55
	NOK/bbl	585	778.05	391.95
Gas price real	NOK/sm3	2	2.66	1.34
	USD/MMBtu	5.86	7.7938	3.93
	USD/fat oe	32.54	43.2782	21.80
	NOK/boe	292.9	389.557	196.24
	Change		**0.03%**	**-0.03%**
Total Costs		166.66	166.710	166.610
Oil	NOK	36.496	36.507	36.485
Gas	NOK	18.772	18.778	18.766
Exploration	NOK	50.84	50.855	50.825
Operations	NOK	60.552	60.570	60.534
Exchange rate	NOK/USD	9		
Discount rate	Percent	3%		

Table 8 consists of basic information and assumptions that help our NPV sensitivity analysis. The table consists of similar basic information with table 4 except for the variable to which changes are introduced as a result of price shock. Following previous empirical researches, it is assumed that a unit percentage change in the price of oil and gas is expected to result in a 0.3 percentage point change in relative cost elements. Having taken this change into account then NPV is calculated and presented in Appendix VI and Appendix VII. The result of the NPV calculation is given by output table 9.

TABLE 9: COST SENSITIVITY SCENARIO OUTPUT

Gross revenue NOK bn			Total cost NOK bn				Total net cash flow	Discounted net cash flow
oil	gas	total	exploration	development	operation	total		
521	134	655	67	74	54	195	460	178
260	90	350	34	37	54	125	225	86

The above table shows a summary of Appendix VI and VII, where the sensitivity of cost relative to price increase and the resulting NPV, as well as a summary of the reaction in cost for relative price reduction and its implication on NPV. combining both directions change in value drivers, we end up with an NPV ranging between NOK 178 bn to NOK 86 bn.

6.1.4.4. Scenario IV- Combined Scenario Sensitivity Analysis:

This is a more generic approach whereby the effect of changes in all of the value drivers can be reflected as a change in independent value driver logically triggers changes in the remaining dependent value drivers. Therefore a 33% change in oil and gas price is estimated to have the same directional movement in the amount of resources to be discovered and all associated costs incurred until commercializing the petroleum. Set of assumptions to describe such co-movements among variables are presented in the following input table 10.

TABLE 10: COMBINED SENSITIVITY SCENARIO INPUT.

Combined Sensitivity Scenario-4				
Variables	Unit	Value	Scenario Adjusted	
			16.5%	**-16.5%**
Recoverable resources:	Bn boe	1271	1481	1061
Oil	Bn bbl	813	947	679
Gas	Bn boe	458	534	382
Oil Price (real)	**Change**		**33%**	**-33%**
	USD/bbl	65	86.45	43.55
	NOK/bbl	585	778.05	391.95
Gas price real	NOK/sm3	2	2.66	1.34
	USD/MMBtu	5.86	7.7938	3.9262
	USD/fat oe	32.54	43.2782	21.8018
	NOK/boe	292.9	389.557	196.243
	Change		**0.03%**	**-0.03%**
Total Costs		166.66	166.710	166.610
Oil	NOK	36.496	36.507	36.485
Gas	NOK	18.772	18.778	18.766
Exploration	NOK	50.84	50.855	50.825
Operations	NOK	60.552	60.570	60.534
Exchange rate	NOK/USD	9		
Discount rate	Percent	3%		

These inputs enable the analysis of how sensitive NPV is for these value drivers happening together to reflect the real life situation. Discounted cash flows and the then resulting NPV figure, whose explicit calculation is depicted in Appendix VIII and Appendix IX is summarized in the following output table-table 11

TABLE 11: COMBINED SENSITIVITY SCENARIO OUTPUT

Gross revenue NOK bn			Total cost NOK bn				Total net cash flow	Discounted net cash flow
oil	gas	total	exploration	development	operation	total		
737	208	945	59	55	71	185	761	321
266	75	341	42	55	51	148	194	66

The above output table shows a summary of Appendix VIII where the increase in price of the resource encourages more exploration and results in more reserve estimates, and more exploration requires more cost associated with, as well as a summary of Appendix XI whereby oil and gas price reduction results in the dampening effort to explore more and results in less amount of cost to be incurred. The first row with figures gives a summary of the calculation for relative increases in the value drivers that could lead to the generation of an NPV of NOK 321bn Norwegian kroner. The second highlighted row summarizes calculation of NPV when the relative decrease is expected which could result in NPV of NOK 66 bn creating the largest range in this analysis.

6.2 Analysis of Indirect Effects:

The second part of our total economic assessment involves indirect impact assessment so that the net economic effect will be included in the total net benefit/loss. It is unequivocal that the commencement of oil and gas extraction in Lofoten or elsewhere will have ripple effects on other sectors indirectly. Some of these effects have favorable impacts in fostering some industry sectors and at the same time, poses some undesirable impacts on others sectors that may even challenge their existence. So, the net economic benefit/loss needs to be taken into account if any meaningful decision that optimizes social welfare is to be made. This part then is entirely dedicated to the assessment of such ripple effects by identifying, evaluating and quantifying them to address their real economic values.

A peculiar characteristic of this part is the fact that we, as researchers, have been tempted by the difficulty and complexity of the analysis. Identifying so many variables as much as possible was the first challenge encountered for it is easy to create an indirect attachment of firms, industries or another economic agent with the commencement of oil and gas industry in the region. Once a variable is identified we were confronted with determining the real effect and its quantification to be included in the analysis. For example, one cannot deny an extensive job opportunity created by the petroleum sector as a positive effect but may fail to realize the fact that this is only short-term employment and can have long term unemployment impact for such projects have an only limited existence. We believe that a thorough investigation should include the net effect of short-term employment and structural adjustment to be made in the future to settle unemployment. For such tempting variable treatment situation appears here and there, we admitted that we can only carry out a partial assessment of the whole analysis required given time restriction. But we need to emphasize that attempts have been made to identify the most important elements and directions have been set for future investigation by whomever willing to launch the same analysis with such a project. Constrained by time limitation some of the elements that should have otherwise been included are excluded, and every time we have excluded them, we have indicated their exclusion by pointing out where the variable should fit into.

6.2.1 Positive Indirect Effects:

Positive indirect effects can be considered as addition income that is going to generate from the petroleum supply sector industry. In this study, we are expecting that there will be potential growth in the petroleum supply sector industry besides direct oil and gas income. New petroleum exploration, development, and extraction will give rise to the supply industry that deals with petroleum supply related activities. For example, construction firms and piping companies will have a boost in their business during the development period, continuous supply of oil and gas need also supporting services that usually given to the third-party companies by the mother companies. This increase in this sector gives rise to addition benefits to the economy that can be considered as indirect benefits. In this study, they are additional income generated from this sector and addition employments.

6.2.1.1 Supply Sector Industry Development:

In order to find the additional revenue that can be earned if Lofoten is open for petroleum activities, this study takes the five years revenue from 2013 to 2017 form current petroleum service sector industry (Ernst & Young, 2018). Then total production during these 5 years Million Sm3 per year collected from the Norwegian ministry of Petroleum and Energy (2019), afterward converted into boe for the calculation purpose. Using production and revenue we identified the per year petroleum supply sector revenue per and made an average supply sector revenue per barrel which is NOK 296.19. Lofoten exploration and development will commence from 2024 and the revenue generation will start from the year 2031 for this particular sector. From 2031 and onward Lofoten yearly forecasted extraction (Mohn, 2019) are multiplied by average revenue per boe and attained the per year supply revenue up to 2070. Thereafter, the industry EBITD (Adjusted earnings before interest and tax + Depreciation and Amortization) is calculated for each year. The average EBITDA of Norwegian fishing industry for 5 years is 9.9% (2013 to 2017) we used as the basis of profit each year from the service sector industry (Ernst & Young, 2018). The present value of these EBITDA aer calculated using a 3 percent discount rate. The total amount of expected benefit from petroleum supply sector is **NOK 17.48 billion** approximately (Appendix X).

6.2.2 Negative Indirect Effects:

Negative indirect effects this study has taken into account are revenue losses from the fishing industry and tourism industry due to accidental oil spills and the oil spill recovery costs. Several studies have shown that an oil spill in Norwegian continental shelf can bring catastrophic consequences (Høgi, 2010) (Misund & Olsen, 2013), even though the possibility of accidental oil spill is minimal (Navrud, Lindhjem, & Magnussen, 2016). A complete cost-benefit analysis of Lofoten is what this study is targeted for and thereby the all kind of possible negative effect we have to take into account. However, as it was mentioned earlier getting into accurate amount is somewhat impossible and, in our findings, we tried to be as much realistic as possible.

6.2.2.1 Loss of Activity and Income from Fishing Industries:

As a part of the cost-benefit analysis of Lofoten, the local fishing industry is expected to be the first sector that going to suffer the adverse consequences of petroleum activities. However, the fishery is not the only sector that is going to suffer due to petroleum exploration but considering the magnitude of monetary loss, this sector comes first to analyze the indirect cost. In our study, income from commercial fishing in this region is an opportunity cost that the Norwegian economy is going to give up in order to earn petroleum income from the same region. There could be several possible reasons that might cause a fishing ban in this region or reduced in fish stock. For example, accidental oil spills, hamper in the natural ecosystem due to the construction of offshore rigs and seismic blast, etc. Even though several factors are related to come up with accurate costs of any of the above-mentioned reasons. If we consider the accidental oil spills, for instance, the seriousness of the damage on the fish and fish stock depends on the quality and quantity of oil spills, time (month) and the weather condition of the spills (Hjermann, et al., 2007). Several studies on previous accidental oil spills (Alvarez, Larkin, Whitehead, & Haab, 2014) (CARSON, et al., 2003) (Loureiro, Ribas, Lopez, & Ojea, 2006) mentioned about the halt in commercial and recreational fishing for some particular number of years which counted as indirect loss from oil spills. The timing of the fishing ban also varies based on the type of fishes. Therefore, it is rather complicated to exactly calculate the loss. On the other hand, the seriousness of accidental oil spills in this kind vulnerable area like Lofoten can be catastrophic. Even though the probability of accidental oil spills is very less yet the possibility cannot be overlooked (Misund & Olsen, 2013). Another study by Helle, Ahtiainen, Luoma, Hänninen, and Kuikka (2015) pointed out that the effect of the oil spill will maximum 10 years in the true state on animal, plants and other biological lives. hence, we considered the worst-case scenario for our study that there will be a 100 percent possibility (Mohn, 2019) of oil spills that will cause a fishing ban for 10 years. Moreover, 6 years of fishing loss during the initial period when the construction of petroleum rigs, pipelines, and other mandatory structures will take place, and this will hamper fishing vessel movement or somehow could hamper fishing. In total there will be a fishing revenue loss for 16 years according to our finding. We are considered a hypothetical oil spill from 2031 during the starting year of oil extraction.

Throughout this petroleum activities life span for 50 years, we are considering a complete ban on commercial fishing for the first 16 years from (2024 to 2040) unless there is any oil spill occurrence in the following years. Consequently, the income that can be earned from this time period will be considered as the indirect cost incurred due to petroleum activities. In our analysis part, the fishing revenue is identified based on the last 10 years average growth rate. Then we identify the EBITDA of the fishing sector that is 15% in 2016 as mentioned by Ernst & Young (2016) report on Norwegian Aquaculture Analysis 2017. The rationality of taking

15% as EBIT is that there was a very fluctuating patern of fishing income throug out the last decade from bellow 10% to 15%. As we mentioned earlier we are taking the worst case scenario and that is why we considere the maximum possible amount that Norway can lose from Lofoten. Annul EBITDAs (profits) are then discounted under the present value mechanism and sum-up.

We have taken the revenue based on catch value of fish of six municipalities of Lofoten county. The municipalities are Vågan, Vestvågøy, Flakstad, Moskenes, Værøy, and Røst. Data on catch value were collected from Norwegian fiskeridirektoratet from 2008 to 2018. These ten years of data are used to find the growth rate of fishing revenue of Lofoten county (Appendix-XI). We identify the annual growth rate for each year from 2008 to 2018 and added these eleven years growth rates divided by number of years and found the average growth rate which is 4.72 percent per year

$$Fishing\ Sector\ Growth\ Rate\ (GR) = \frac{\sum percentage\ change\ in\ fish\ catch\ of\ each\ year}{Number\ of\ years}$$

$$= 4.72\%$$

$$PV = \frac{FI_{Cf\ 2024}}{(1+r)^{t_4}} + \frac{FI_{Cf\ 2025}}{(1+r)^{t_5}} + \cdots + \frac{FI_{Cf\ 2040}}{(1+r)^{t_{20}}} = \text{NOK 4.95 bn}$$

This 1.8 percent growth rate is adjusted to estimate the projected catch values for the course of 16 years from 2024 to 2040. Then the amount of catch value during the 16 years span which is represented by *"t"* were discounted by 3 percent which is the rate of return from the Norwegian GPF represented by *"r"* and came up with the present value (PV) of the 16 years projected revenue (FI= fishing income). Even though the industry growth rate of this industry is 18.5 percent in 2016. But the magnitude of fluctuation of every year growth rate is comparatively high. Moreover, the industry growth rate is measured based on overall Norway to illustrate national growth. Whereas, the local growth is comparatively consistent hence more logical to take into consideration. In addition, the local growth rate of these six municipalities will give a more accurate and realistic projection of the catch values. The sum of net loss after discounting is **NOK 4.95 billion**. We assume that the income loss due to unemployment in the fishing sector is also included in the income from the fishing sector. If it is included separately, then there will be double count of unemployment. Because the income of the fishermen is included in the catch value.

6.2.2.2 Loss of Activity and Income from Tourism Industry:

Likewise fishing we are also expecting a 16 years revenue loss from the tourism sector. As first 6 years due to construction and development activities by petroleum industries will cause less tourist to attract toward Lofoten. Afterward due to the hypothetical oil spill may cost another 10 years of a significant reduction ina number of tourists. As we are considering the worst-case scenario, we expect there will be a 100 percent reduction in a number of tourists. As per Mohn (2018) during summer where most of the tourists visit Lofoten, around 350,000 tourists visit there. Moreover, there are about 14% of the total tourists are corporate visits which doesn’t include recreational visits that somewhat offset for not including winter tourism. The tourist sometimes very less or have negative growth during the winter season because of that tourists during winter didn’t take into the calculation. According to Innovation Norway Report (2018), total tourist consumption in entire Norway was NOK 170 billion in 2017. About 10.18 million tourists visited that year including both domestic and foreigners (SSB, 2018). Average consumption per tourist is NOK 167 for Norway in 2017. By multiplying this average consumption per tourist with a number of tourists in the Lofoten area we get the amount of tourist consumption for the region for 2017. (Appendix-XII)

$$PV = \frac{TR_{Cf\ 2024}}{(1+r)^{t_4}} + \frac{TR_{Cf\ 2025}}{(1+r)^{t_5}} + \cdots + \frac{TR_{Cf\ 2040}}{(1+r)^{t_{20}}} = \text{NOK } 56.7 \text{ billion}$$

This amount is then adjusted with the tourism industry growth rate which is 4.51% (Appendix X) which is the average growth of last 8 years tourist consumption of Norway (Innovation Norway;, 2018). Afterward, the remaining PV calculation follows a similar process likewise tourism. TR is the tourism revenue which taken from 2024 which is the fourth year and 2040 is the 20th year. The discount rate is denoted with r that is equal to 3%. Discounted cashflows are calculated by using a 3% discount rate and sum-up to last 16 years probable revenue loss that is **NOK 56.7 billion** approximately.

6.2.3 Analysis of Oil Spill Recovery Cost:

A very important part of the cost analysis of oil spill is to assign the clean-up cost. As an immediate response to oil spill accident weather, it’s a spill from rig, tanker or pipeline, the clean-up ships come into the recovery action in the beginning. Followed by, the government employed teams, rescue parties and volunteers. There are several studies which tried to figure out cleanup costs in different ways for the previous oil spills accidents. These cleanup costs vary based on the different factors like quality and quantity of oil spills, weather condition, geographical positioning, and many other factors. Without any doubt, it is a very complicated analysis to calculate and come up with an exact amount of cleanup of an actual oil spill case. Moreover, assigning a cleanup cost to a hypothetical oil spill is even way more complicated. In a real-life oil spill cases, the actual data are mostly available. On the contrary, the scenario is not the same for hypothetical oil spill cases. The analysis mostly depends on logically analyzing the previous oil spill data and fit these data into the expected oil spill area in an appropriate manner. In short, the aftermath of a hypothetical oil spill is harder than a real oil spill. The highest oil spill was 12700 m3 in quantity during 1977 and 4400 m3 in 2007 is the latest (Bakos , 2009). A study by (Konotovas, Psaraftis, & Ventikos, 2010) on oil spill cleanup cost valuation came up with a per tonne clean-up cost USD 1639. They studied the International Oil Pollution Compensation Fund (IOPCF) data based on different oil spills and came up with this amount that we found considerable enough to use in our study. Since the amount was based on the year 2009, so we have to come with the inflation adjusted amount which is **USD 1956.47** or **NOK 17608.23** in 2019. An impact study was conducted by Caroll, et all (20180 on oil spills on the Northeast Arctic came up with a different combination of oil spill quantity and duration and its effect on cod fishing and its stock. Even though this analysis was on cod fishing, but their oil spills simulation scenarios gave us a strong foundation on the probable amount of oil spills specifically in the Northeast Arctic area where the Barents Sea and Lofoten area is included. They scenarios included a combination of 1500 m3 per day to 4500 m3 per day oil spill which will continue for 15, 45- and 90-days categories. For our study, we took the averages those are **3000m3** oil spill per day for **45** days. As 15 days is comparatively less, and 90 days is highly unlikely to occur since it is the oil spill duration for Deep Water Horizon and the number of oil wells in the Gulf of Mexico is higher than the North Sea (Hauge, et al., 2014). The amount of probable oil spill in the Lofoten area is 135,000 m3 or **47674.80 tonne** and total expected clean-up cost is **NOK 0.8395 billion.**

6.3 Analysis of Externalities:

The third factor that needs to be analyzed to come up with a total economic evaluation of a project is externality effect analysis. Even though externality can have positive or negative consequences, the latter case is the peculiar characteristics of the project we have at hand-petroleum extraction. Hence, we focus entirely on corresponding adverse consequences to which monetary value can be attached to in the form of cost that society is likely to incur incase the project is commenced. By externality, we refer here to environmental degradation that is confronted incase oil spill occurs with an extended unwanted result on the ecosystem, animal life, and the quality of the region as a preferred destination for tourism. Many previous researches have shown that such unfortunate mis happenings in the past had catastrophic consequences on bird lives, fish stocks and recreational quality of a given region.

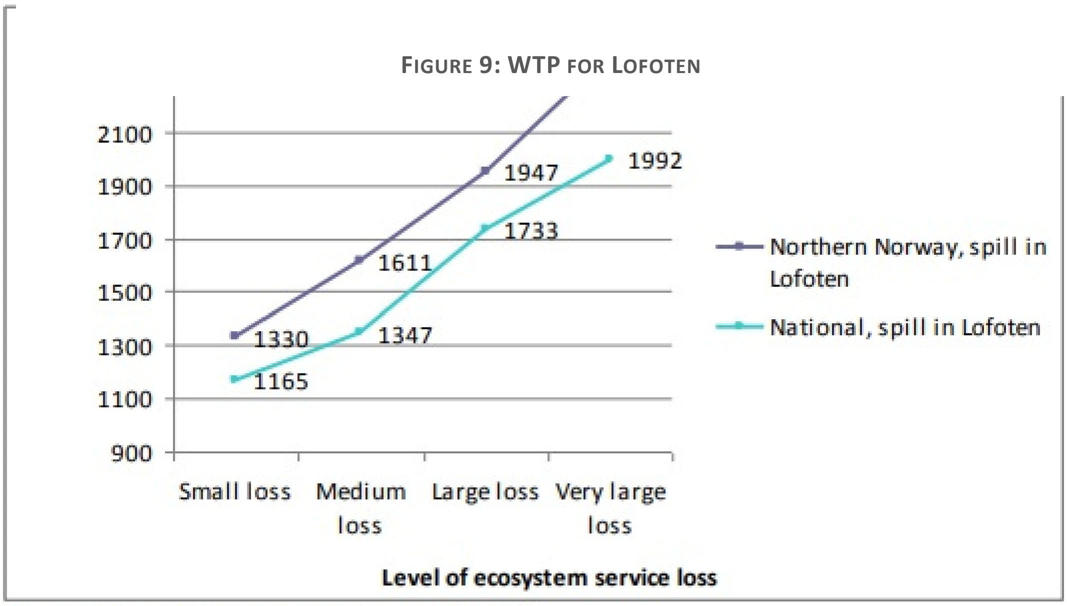
For the sake of economic analysis, the important thing here is then the cost implications associated with externality when such a project is planned. It is important at the same time to note that such cost implication is not as simple and easy as it is in calculating direct costs. This is because the elements under consideration lack standard market value and call for special method to deal with them. One of the most common and widely used method in valuing non-market goods is the one that is entirely depend upon survey method to pinpoint how much a society is willingness to pay to keep a region intact or the amount of willingness to accept to let the project in the region.

Willingness to pay (WTP)is the average amount of monetary value that concerned people are willing to pay in order to ban the commencement of projects with an intension of avoiding a corresponding adverse consequence. Accordingly, previous studies have tried to provide quantitative figures that Norwegian households are willing to pay in order to keep the Lofoten region intact for the coming 10 years. For example, according to studies done by Navrud, Lindhjem, & Magnussen (2016), on an average the willingness to pay for avoidance of oil spills in Lofoten ranges between NOK 1300 and NOK 2400 per household per year depending up on how serios the amount of losses would be.

Navrud, Lindhjem, & Magnussen (2016) and his group carried out extensive contingent valuation studies to determine a willingness to pay by the Norwegian households to prevent the loss of the ecosystem due to the oil spill. From amongst the three Norwegian regions analyzed separately, the Lofoten region had shown a higher willingness to pay than other regions. In this study, we preferred to take a national level study as it is more representative of the attitudes of Norwegian households at large rather than coastal people whose livelihood is highly dependent on fishing and tourism around their region.

The following table shows different amount of willingness to pay among Norwegians for different levels of loss exposures at a regional level and at a national level as indicated by blue and green line respectively.

FIGURE 8: WTP FOR LOFOTEN



Source: Navrud, Lindhjem, & Magnussen (2016)

As the level of loss that is likely to occur can be one of these four scenarios(small loss, medium loss large loss and very large loss), we preferred to take the average of the willingness to pay for the national level and base our calculation of NPV on it(1165+1347+1733+1992/4=1559). we have assumed also the same willingness will at least continue to prevail the next fifty years by extending Navrud´s projection to 2070. Following the same study, 2.2 million Norwegian households are taken into account and the average amount of WTP of NOK 1559 for the following 50 years is discounted at 3% using the ordinary annuity formula:

$PV = R[1 - (1 + r)^{-n}]/r$

Where,

PV = present value at year 2020

R = annual WTP for 2.2 million households (2.2m x1559=3,429,800,000)

r = annual interest rate (3%), and n=number of years (50 years)

Substituting these figures into the above formula would give us a present value of approximately **NOK 88** billion that major public is willing to pay to protect the region intact and thereby avoid associated risks for the following fifty years. It follows then the project under consideration should critically be evaluated in such a way that is able to cover at least what Norwegians are willing to pay to ban it in addition to other relevant costs before it is unleashed to the region.

Finally, an important and an unescapable part of externality analysis is an irreversible emission of CO_2, which needs to be taken into account and be reflected in the full assessment of the evaluation of petroleum extraction activities. Norway's oil and gas extraction is included in the EU Emissions trading system (ETS) for CO_2 quotas and is also subject to a specific Norwegian CO_2 tax. The result is a cost of CO_2 emissions of around NOK 500 (USD 62.5) per metric ton in the Norwegian oil and gas industry (Mohn, 2019). International organizations like IEA and IRENA have recommended even imposing higher CO_2 tax, which should increase to the level of USD 190 if the ambitions of the Paris agreements need to be met. In this study, however, we adhere to the already existing carbon tax rate, adjust it for the difference in the exchange rate; and calculate PV for the carbon tax expenses over the production life of the project.

The calculation follows a simple procedure whereby annual production from the year 2030 to 2070 is converted into its equivalent metric ton of production using standard conversion method and multiplied by CO_2 emissions per metric ton NOK 558, which gives a cash flow of presumed carbon tax per year. The present value of these cash flows is discounted to the year 2020 to give NOK **47.7 bn** approximately as carbon tax expense the society is expected to incur if Lofoten is allowed to host petroleum companies.

In general, these associated costs and benefits that inevitably crop up here and there as a result of such highly valuable project in a highly sensitive area should carefully be analyzed and their economic implications must be be known. A summary of all of these variables discussed in this part and the discussion of their implication is presented in the following part, after which one can really identify and understand the rationale behind the dilemma, we have confronted in Lofoten.

Part Seven: Discussion

Tedious calculations we went through and a number of variables manipulated in the analysis part may divert once attention as a reader from the purpose this complexity is meant for. A cost -benefit method of evaluation, which seems relatively simple and easy, is not as simpler and easier as it is expected practically. The method which basically requires the identification and quantification of costs and benefits is now ready to be summarized to show the net result. We would like to emphasize two things here. Firstly, even though our main goal was to carry out the whole assessment of the economic valuation of petroleum project in Lofoten region, we have ascertained that our analysis has turned out to be an only partial assessment as a result of partly time limitation and partly lack of basic synchronized data on some important variables. Secondly, quantification of the identified variables may slightly be different from other related studies due to partly some adjustments made to reflect existing market condition or due to some other approaches we preferred to follow.

In general, this part tries to discuss the findings by giving a brief summary without going into that much detail. For the sake of easy discussion, the results of our analysis are first presented in the following cost-benefit balance sheet where figures from reference scenario are taken into account.

TABLE 12: THE COST-BENEFIT BALANCE SHEET

Cost-Benefit Balance Sheet on Lofoten					
Costs	**Amount (NOK bn)**		**Benefits**	**Amount (NOK bn)**	
Direct Costs:			**Direct Revenue:**		
Direct Costs	67		Direct Revenu	246	
Total Direct Costs		**67**	***Total Direct Revenue***		***246***
			Indirect Revenue:		
Indirect costs:			Income from Supply Sector	17.48	
Losses from fishing	4.95				
Losses from tourism	56.70		***Total Indirect Revenue***		***17.48***
Probable Oil spill Clean-up Costs	0.8395				
Total Indirect Costs		***62.49***			
External Costs:					
Environmental Costs (WTP)	88				
CO_2 emmssion costs	48				
Total External Costs		***135.70***			
Total Costs		**265.19**	***Total Revenue***		**263.48**
Net Effect: Net Loss (bn)			**-1.71**		

The cost benefit balance sheet presented above is prepared following our analysis result indicated by our reference scenario from direct effect analysis; results from indirect effect analysis, and values resulting from adverse consequences of externality.

According to the reference scenario the net present value of the project, when only direct costs are taken into account, turns out to be positive and reaching NOK 179 bn. Moreover, the huge amount of profit of NOK 152 bn (85 % of NOK 179 bn as a share of government) is more than enough for the government to approve the project in the region. Despite the fact that the results of other scenarios in the analysis have not presented here in the balance sheet, their calculations show that they are no exceptions to give a green signal for the commencement of the project (Appendix XV). Since the scenarios are based on sensitivity analysis and expected a different combination of variables that will change over time. However, the sensitivity analysis of different other sceneries have both positive and negative outcome but once should be really optimistic or pessimistic while choosing any of the reference scenarios. We gave them a window for the future researches to what different combination of variables can look like. Ranging from the lowest NPV of NOK 66 bn to the highest NPV of NOK 371 bn that can be reaped as per combined scenario, all give the same positive signal to decision making at least theoretically; even though their motivational impact obviously differs significantly between the amount of rate of return on investment. A net benefit of NOK 66 bn will not have equal contribution to either increase annual government budget or provide tax concession with a net benefit of NOK 321bn.

Had it not been for the positive NPV implication we came to realize whatsoever the case under direct effect analysis under all scenario possibilities, the second part of consideration (indirect benefits) would have not been an issue to attract attention for the decision maker- possibly the government here. Unlike private investors, governments need to consider for possible influences that such huge projects would be able to bring about to the economy in the short run as well as possibly long run.

Broadly speaking these effects have been described as having either favorable impact or unfavorable impact. Employment and the development of service and supply sectors have been identified as a positive contribution, whereas wage pressure that is likely to prevail and a situation by which traditional industries crowd out are among potential negative consequences.

Even though identifying and quantifying the amount of economic benefit from employment and adding it to net benefit can be logical procedure, its treatment in the analysis has become complex due to; lack of data about competitive wage pressure created, which might have otherwise been deducted from positive contribution of employment ; and the need to avoid double counting for labor expense has been solidly included in the direct cost of oil companies or other industries that are likely to emerge. So then besides describing employment as an advantage, it is not included in the calculation.

Dealing with economic benefits from supply and service sectors that are expected to flourish with the commencement of the project is even more difficult for which we made a loose projection from national data. Accordingly, a total benefit of NOK 17.5 bn is expected to be raised from these related sectors that will add up on to total benefit.

The unfavorable ones are clearly indicated in the balance sheet and are represented by the revenue losses both from fishery and tourism sectors, which are approximately NOK 56.7bn and NOK 5 bn from two sectors respectively. Cost of probable oil spill clearing of NOK 850 million is expected to be incurred and is also part and parcel of the project in case oil spill occurs.

The net amount of indirect effect of the potential loss of NOK 45 bn is subtracted from the amount indicated by the net direct effect to come up with the new net effect created as a result of indirect effect considerations. This result then has a decision implication impact at which decision makers will reconsider the statusquo that they had under direct effect analysis. In our case, this amounts to NOK 135.7 bn, under which case the project is recommended.

If the project successfully passes the above two basic evaluation, there could be still one more test through which the project makes its final journey to prove its viability. This is the third part indicated on the balance sheet consists basically of two elements as external costs. cost of preventing environmental degradation is reflected by the cost that the society is willing to accept which is NOK 88 bn, and the cost of a carbon tax is estimated to be NOK 47.7 bn and summing up to externality cost of approximately NOK 136 bn. This is a huge cost that oil companies do not take into account in evaluating the cost of their investment portfolio when deducted from the net amount we have in the second part results in a net loss of approximately NOK 1.71 bn. It follows then the total welfare benefit that the project is going to generate to the society is far less than the social cost the society faces from this project as a result of which the project will definitely be rejected.

Part Eight: Conclusion

A thorough investigation of the pros and cons of petroleum activity in the Lofoten region has been the focal point of analysis in this paperwork. Accordingly, we have carried out a closer look and assessments to those effects and categorized them as having either a positive effect or negative effect in an attempt made to determine the total economic impact of the project.

The three sub parts of the analysis have produced a sound result that can be used either separately or in common. The first part of the analysis clearly provided a robust output that supports the commencement of the project. But because the essential part of our analysis is total economic impact assessment, positive economic direct net benefits have been offset by the sum of net indirect and external effects. This has a clear policy implication for policy makers as total social loss cannot be covered by positive economic effects of the project, and rejecting the project is considered a wise rational decision.

Besides the spectrum of using a quantitative approach to decision making, we need to address the need to consider qualitative factors before making any meaningful decision; and hence object the quantitative result we came across in our analysis. This is because the closer look and analysis of this paperwork has enabled us to understand qualitative factors that no quantitative value can be assigned to, but believed to have a major impact on decision making. Here are some of our point of argument:

1. The Lofoten region has already been exposed to the danger of oil spill by passing by oil tanker from Russian oil fields in the Barents Sea and potential crude oil transporter ships from extensive Norwegian petroleum fields in the north. Moreover; the danger from wells have been recorded to have fewer effects than the danger from oil spills from passing by oil tankers. Hence we argue that no surprise is going to take place in the region for the feared danger is already there, and we believe losing petroleum revenue from that region for the fear of low risk from oil wells in the region while the region is dealing with the worst case is irrational.

2. The fact that petroleum extraction activities are only done 70 kilometers away from the coasts, would destroy the argument that platforms can have dampening visual quality for tourism. On the other hand, we believe petroleum processing facilities to be done on the mainland can be done on the nearby facilities without touching the mainland of the region to ensure co-existence of tourism with the petroleum industry

3. Oil spill risks encountered by Norwegian so far, strict safety procedures set; and accumulated skills, technology and expertise acquired by Norwegian can be a buffer to maximally minimize the risk of the project. The relative insignificant oil spill case Norway has so far been exposed to in its continental shelf coupled with the strict safety requirements during licensing are strong qualitative grounds. The argument that the country has delayed the project in the region due to lack of knowledge to assess the amount of loss in case of oil spill thirty years ago is now baseless when we evaluate technological advancement the country has achieved today. Attempts that are being made to exploit petroleum resources even further north is a clear indication that oil companies have developed the technology level and capacity that allows them to face the challenges of even harsher regions.

In general, then we believe relaying only on quantitative results like the one we presented in this paper to make a decision is not necessary and sufficient condition to measure the soundness of the project like this one. Consideration of other important elements would help decision in no equivalent way that numbers can tell. Therefore, we believe that the aforementioned observations we have made during our analysis will help decision makers to be more pragmatic and would make them create a situation by which petroleum sector together with fishingand tourism co-exist in the region to optimize economic importance of the Lofoten, without any environmental degradation.

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Appendices:

Appendix I: The Reference Scenario

(calculation by using the model of Mohn (2019)):

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.271**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**65**
	NOK/bbl		*585*
Gas price	*NOK/SM³*		**2.00**
	USD/MMBtu		*5.86*
	USD/boe		*32.54*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.44*
	NOK per boe		**40.00**
Total	*USD bn*		*5.65*
102	*NOK bn*		*50.84*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.660*
Oilfield		*22%*	*36.496*
Gas field		*11%*	*18.772*
Exploration		*31%*	*50.840*
Operation		*36%*	*60.552*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploration	*Field development (NOK bn)*			*Extraction (1,000 boe per year)*			*Gross revenue (NOK bn)*			*Cost of operation (NOK bn)*			*Total cash flow (NOK bn)*			*Total DCF @3% (NOK bn)*		
		Oil field develo	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	counted ca
Sum	**51**	**37**	**19**	**55**	**813**	**458**	**1,271**	**476**	**134**	**610**	**42**	**19**	**61**	**366**	**79**	**444**	**159**	**20**	**179**
2020																			
2021																			
2022																			
2023																			
2024	0.975																		
2025	2.842													-1.819	-1.023	-2.842	-1.479	-0.832	-2.311
2026	5.281	0.025		0.025										-3.405	-1.901	-5.306	-2.688	-1.501	-4.188
2027	7.196	1.202		1.202										-5.807	-2.591	-8.398	-4.451	-1.986	-6.436
2028	7.865	8.316		8.316										-13.350	-2.831	-16.181	-9.934	-2.107	-12.040
2029	7.313	14.487		14.487										-19.168	-2.633	-21.801	-13.847	-1.902	-15.749
2030	6.028	9.199		9.199										-13.057	-2.170	-15.227	-9.158	-1.522	-10.680
2031	4.534	2.749	0.013	2.762	24.831		24.831	14.526		14.526	1.132		1.132	7.743	-1.645	6.098	5.273	-1.120	4.152
2032	3.179	0.464	0.618	1.082	30.181		30.181	17.656		17.656	1.228		1.228	13.929	-1.763	12.167	9.209	-1.165	8.044
2033	2.111	0.050	4.278	4.328	33.991		33.991	19.885		19.885	1.297		1.297	17.186	-5.038	12.149	11.031	-3.233	7.798
2034	1.343	0.050	7.452	7.502	36.412		36.412	21.301		21.301	1.341		1.341	19.051	-7.935	11.115	11.872	-4.945	6.927
2035	0.827		4.731	4.731	37.687		37.687	22.047		22.047	1.363		1.363	20.154	-5.029	15.125	12.193	-3.043	9.151
2036	0.496		1.414		38.060	13.222	51.282	22.265	3.872	26.138	1.370	0.530	1.900	20.578	1.750	22.328	12.087	1.028	13.115
2037	0.291		0.239		37.754	14.071	51.825	22.086	4.121	26.207	1.365	0.538	1.902	20.535	3.240	23.775	11.711	1.848	13.559
2038	0.168		0.026		36.952	14.619	51.571	21.617	4.282	25.899	1.350	0.543	1.893	20.159	3.652	23.811	11.162	2.022	13.184
2039	0.096				35.801	14.957	50.758	20.944	4.381	25.324	1.330	0.546	1.875	19.553	3.800	23.353	10.511	2.043	12.553
2040	0.054				34.416	15.145	49.561	20.134	4.436	24.569	1.305	0.547	1.852	18.794	3.869	22.663	9.809	2.019	11.828
2041					32.886	15.225	48.111	19.238	4.459	23.697	1.277	0.548	1.825	17.961	3.911	21.872	9.101	1.982	11.082
2042					31.275	15.226	46.501	18.296	4.460	22.755	1.248	0.548	1.796	17.048	3.911	20.959	8.386	1.924	10.311
2043					29.633	15.168	44.801	17.335	4.443	21.778	1.218	0.548	1.766	16.117	3.895	20.012	7.697	1.860	9.558
2044					27.996	15.067	43.063	16.378	4.413	20.791	1.189	0.547	1.736	15.189	3.866	19.055	7.043	1.793	8.836
2045					26.390	14.932	41.322	15.438	4.374	19.811	1.160	0.545	1.706	14.278	3.828	18.106	6.428	1.723	8.151
2046					24.831	14.774	39.605	14.526	4.327	18.853	1.132	0.544	1.676	13.394	3.783	17.177	5.854	1.653	7.508
2047					23.333	14.598	37.930	13.650	4.275	17.925	1.105	0.542	1.648	12.545	3.733	16.278	5.323	1.584	6.907
2048					21.902	14.408	36.310	12.813	4.220	17.033	1.079	0.541	1.620	11.733	3.679	15.413	4.834	1.516	6.350
2049					20.543	14.210	34.753	12.018	4.162	16.180	1.055	0.539	1.594	10.963	3.623	14.586	4.385	1.449	5.834
2050					19.257	14.005	33.263	11.265	4.102	15.367	1.032	0.537	1.569	10.234	3.565	13.799	3.974	1.384	5.359
2051					18.045	13.797	31.842	10.556	4.041	14.597	1.010	0.535	1.545	9.546	3.506	13.052	3.599	1.322	4.921
2052					16.905	13.586	30.491	9.889	3.979	13.869	0.989	0.533	1.523	8.900	3.446	12.346	3.258	1.261	4.519
2053					15.835	13.374	29.209	9.264	3.917	13.181	0.970	0.531	1.502	8.293	3.386	11.679	2.947	1.203	4.151
2054					14.833	13.163	27.996	8.677	3.855	12.533	0.952	0.530	1.482	7.725	3.326	11.051	2.665	1.147	3.813
2055					13.895	12.953	26.848	8.128	3.794	11.922	0.935	0.528	1.463	7.193	3.266	10.459	2.410	1.094	3.504
2056					13.018	12.745	25.762	7.615	3.733	11.348	0.919	0.526	1.445	6.696	3.207	9.903	2.178	1.043	3.221
2057					12.199	12.539	24.737	7.136	3.672	10.809	0.905	0.524	1.429	6.232	3.148	9.380	1.968	0.994	2.962
2058					11.434	12.335	23.769	6.689	3.613	10.302	0.891	0.522	1.413	5.798	3.091	8.889	1.777	0.948	2.725
2059					10.720	12.135	22.855	6.271	3.554	9.825	0.878	0.520	1.398	5.393	3.034	8.427	1.605	0.903	2.508
2060					10.054	11.939	21.993	5.881	3.497	9.378	0.866	0.519	1.385	5.015	2.978	7.994	1.449	0.861	2.310
2061					9.432	11.746	21.178	5.518	3.440	8.958	0.855	0.517	1.372	4.663	2.923	7.586	1.308	0.820	2.128
2062					8.852	11.556	20.408	5.179	3.385	8.563	0.844	0.515	1.360	4.334	2.870	7.204	1.181	0.782	1.962
2063					8.311	11.370	19.681	4.862	3.330	8.192	0.835	0.513	1.348	4.027	2.817	6.844	1.065	0.745	1.810
2064					7.807	11.188	18.994	4.567	3.277	7.844	0.826	0.512	1.337	3.741	2.765	6.506	0.961	0.710	1.670
2065					7.335	11.009	18.345	4.291	3.225	7.516	0.817	0.510	1.327	3.474	2.714	6.188	0.866	0.677	1.543
2066					6.896	10.835	17.730	4.034	3.173	7.207	0.809	0.509	1.318	3.225	2.665	5.889	0.780	0.645	1.425
2067					6.485	10.664	17.149	3.794	3.123	6.917	0.802	0.507	1.309	2.992	2.616	5.608	0.703	0.615	1.318
2068					6.101	10.496	16.598	3.569	3.074	6.644	0.795	0.506	1.300	2.774	2.569	5.343	0.633	0.586	1.219
2069					5.743	10.333	16.076	3.360	3.026	6.386	0.788	0.504	1.293	2.571	2.522	5.094	0.569	0.559	1.128
2070					5.408	10.173	15.581	3.164	2.979	6.143	0.782	0.503	1.285	2.381	2.477	4.858	0.512	0.533	1.045

Appendix II: The Price Sensitivity Analysis

(calculated by using the model of Mohn (2018)- 33% increase in oil and gas prices)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.271**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**86**
	NOK/bbl		*778*
Gas price	*NOK/SM*^{3}		**2.66**
	USD/MMBtu		*7.79*
	USD/boe		*43.27*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.44*
	NOK per boe		**40.00**
Total	*USD bn*		*5.65*
102	*NOK bn*		*50.84*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.660*
Oil field		*22%*	*36.496*
Gas field		*11%*	*18.772*
Exploration		*31%*	*50.840*
Operation		*36%*	*60.552*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploration	Field development (NOK bn)			Extraction (1,000 boe per year)			Gross revenue (NOK bn)			Cost of operation (NOK bn)			Total cash flow (NOK bn)			Total DCF @3% (NOK bn)		
		Oil field develo	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
Sum	**51**	**37**	**19**	**55**	**813**	**458**	**1,271**	**633**	**178**	**811**	**42**	**19**	**61**	**523**	**123**	**646**	**233**	**37**	**270**
2020																			
2021																			
2022																			
2023																			
2024	0.975																		
2025	2.842													-1.819	-1.023	-2.842	-1.479	-0.832	-2.311
2026	5.281	0.025		0.025										-3.405	-1.901	-5.306	-2.688	-1.501	-4.188
2027	7.196	1.202		1.202										-5.807	-2.591	-8.398	-4.451	-1.986	-6.436
2028	7.865	8.316		8.316										-13.350	-2.831	-16.181	-9.934	-2.107	-12.040
2029	7.313	14.487		14.487										-19.168	-2.633	-21.801	-13.847	-1.902	-15.749
2030	6.028	9.199		9.199										-13.057	-2.170	-15.227	-9.158	-1.522	-10.680
2031	4.534	2.749	0.013	2.762	24.831		24.831	19.320		19.320	1.132		1.132	12.537	-1.645	10.892	8.537	-1.120	7.417
2032	3.179	0.464	0.618	1.082	30.181		30.181	23.483		23.483	1.228		1.228	19.756	-1.763	17.993	13.061	-1.165	11.896
2033	2.111	0.050	4.278	4.328	33.991		33.991	26.446		26.446	1.297		1.297	23.748	-5.038	18.711	15.243	-3.233	12.010
2034	1.343	0.050	7.452	7.502	36.412		36.412	28.331		28.331	1.341		1.341	26.080	-7.935	18.145	16.252	-4.945	11.307
2035	0.827		4.731	4.731	37.687		37.687	29.322		29.322	1.363		1.363	27.429	-5.029	22.400	16.595	-3.043	13.553
2036	0.496		1.414		38.060	13.222	51.282	29.613	5.149	34.761	1.370	0.530	1.900	27.925	3.026	30.951	16.403	1.777	18.181
2037	0.291		0.239		37.754	14.071	51.825	29.375	5.479	34.854	1.365	0.538	1.902	27.824	4.598	32.422	15.867	2.622	18.490
2038	0.168		0.026		36.952	14.619	51.571	28.751	5.693	34.443	1.350	0.543	1.893	27.293	5.063	32.356	15.111	2.803	17.915
2039	0.096				35.801	14.957	50.758	27.855	5.824	33.679	1.330	0.546	1.875	26.464	5.244	31.708	14.226	2.819	17.045
2040	0.054				34.416	15.145	49.561	26.778	5.898	32.675	1.305	0.547	1.852	25.438	5.331	30.769	13.276	2.782	16.058
2041					32.886	15.225	48.111	25.587	5.929	31.515	1.277	0.548	1.825	24.310	5.381	29.690	12.317	2.726	15.044
2042					31.275	15.226	46.501	24.333	5.929	30.262	1.248	0.548	1.796	23.085	5.381	28.466	11.356	2.647	14.004
2043					29.633	15.168	44.801	23.056	5.907	28.963	1.218	0.548	1.766	21.837	5.359	27.196	10.430	2.559	12.989
2044					27.996	15.067	43.063	21.782	5.867	27.649	1.189	0.547	1.736	20.593	5.320	25.914	9.549	2.467	12.016
2045					26.390	14.932	41.322	20.532	5.815	26.347	1.160	0.545	1.706	19.372	5.269	24.642	8.721	2.372	11.093
2046					24.831	14.774	39.605	19.320	5.753	25.073	1.132	0.544	1.676	18.188	5.209	23.397	7.949	2.277	10.226
2047					23.333	14.598	37.930	18.154	5.684	23.839	1.105	0.542	1.648	17.049	5.142	22.191	7.235	2.182	9.417
2048					21.902	14.408	36.310	17.041	5.611	22.652	1.079	0.541	1.620	15.962	5.070	21.031	6.576	2.089	8.665
2049					20.543	14.210	34.753	15.983	5.533	21.517	1.055	0.539	1.594	14.929	4.994	19.923	5.971	1.998	7.969
2050					19.257	14.005	33.263	14.983	5.454	20.437	1.032	0.537	1.569	13.951	4.917	18.868	5.418	1.909	7.327
2051					18.045	13.797	31.842	14.040	5.373	19.412	1.010	0.535	1.545	13.030	4.837	17.867	4.913	1.824	6.736
2052					16.905	13.586	30.491	13.153	5.290	18.443	0.989	0.533	1.523	12.164	4.757	16.921	4.452	1.741	6.194
2053					15.835	13.374	29.209	12.321	5.208	17.529	0.970	0.531	1.502	11.350	4.677	16.027	4.034	1.662	5.696
2054					14.833	13.163	27.996	11.541	5.126	16.666	0.952	0.530	1.482	10.589	4.596	15.185	3.653	1.586	5.239
2055					13.895	12.953	26.848	10.811	5.044	15.855	0.935	0.528	1.463	9.876	4.516	14.392	3.308	1.513	4.821
2056					13.018	12.745	25.762	10.129	4.963	15.091	0.919	0.526	1.445	9.209	4.437	13.646	2.995	1.443	4.438
2057					12.199	12.539	24.737	9.491	4.883	14.374	0.905	0.524	1.429	8.587	4.359	12.945	2.711	1.376	4.087
2058					11.434	12.335	23.769	8.896	4.804	13.700	0.891	0.522	1.413	8.005	4.281	12.287	2.454	1.312	3.767
2059					10.720	12.135	22.855	8.341	4.726	13.066	0.878	0.520	1.398	7.463	4.205	11.668	2.221	1.252	3.473
2060					10.054	11.939	21.993	7.822	4.649	12.471	0.866	0.519	1.385	6.956	4.130	11.087	2.010	1.194	3.204
2061					9.432	11.746	21.178	7.339	4.574	11.913	0.855	0.517	1.372	6.484	4.057	10.541	1.819	1.138	2.957
2062					8.852	11.556	20.408	6.888	4.500	11.388	0.844	0.515	1.360	6.043	3.985	10.028	1.646	1.085	2.731
2063					8.311	11.370	19.681	6.467	4.428	10.894	0.835	0.513	1.348	5.632	3.914	9.546	1.489	1.035	2.524
2064					7.807	11.188	18.994	6.074	4.357	10.431	0.826	0.512	1.337	5.248	3.845	9.093	1.347	0.987	2.335
2065					7.335	11.009	18.345	5.707	4.287	9.994	0.817	0.510	1.327	4.890	3.777	8.667	1.219	0.941	2.160
2066					6.896	10.835	17.730	5.365	4.219	9.584	0.809	0.509	1.318	4.556	3.710	8.266	1.103	0.898	2.000
2067					6.485	10.664	17.149	5.046	4.152	9.198	0.802	0.507	1.309	4.244	3.645	7.889	0.997	0.856	1.854
2068					6.101	10.496	16.598	4.747	4.087	8.835	0.795	0.506	1.300	3.952	3.582	7.534	0.902	0.817	1.719
2069					5.743	10.333	16.076	4.468	4.024	8.492	0.788	0.504	1.293	3.680	3.519	7.199	0.815	0.779	1.594
2070					5.408	10.173	15.581	4.208	3.961	8.169	0.782	0.503	1.285	3.425	3.459	6.884	0.737	0.744	1.480

Appendix III: The Price Sensitivity Analysis

(Calculated by using the model of Mohn (2018) - 33% decrease in oil and gas prices:)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.271**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**44**
	NOK/bbl		*392*
Gas price	*NOK/SM³*		**1.34**
	USD/MMBtu		*3.93*
	USD/boe		*21.80*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.44*
	NOK per boe		**40.00**
Total	*USD bn*		*5.65*
102	*NOK bn*		*50.84*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.660*
Oil field		*22%*	*36.496*
Gas field		*11%*	*18.772*
Exploration		*31%*	*50.840*
Operation		*36%*	*60.552*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploration	*Field development (NOK bn)*			*Extraction (1,000 boe per year)*			*Gross revenue (NOK bn)*			*Cost of operation (NOK bn)*			*Total cash flow (NOK bn)*			*Total DCF @3% (NOK bn)*		
		Oil field develo	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	counted ca
Sum	**51**	**37**	**19**	**55**	**813**	**458**	**1,271**	**319**	**90**	**409**	**42**	**19**	**61**	**208**	**35**	**243**	**84**	**3**	**87**
2020																			
2021																			
2022																			
2023																			
2024	0.975																		
2025	2.842													-1.819	-1.023	-2.842	-1.479	-0.832	-2.311
2026	5.281	0.025		0.025										-3.405	-1.901	-5.306	-2.688	-1.501	-4.188
2027	7.196	1.202		1.202										-5.807	-2.591	-8.398	-4.451	-1.986	-6.436
2028	7.865	8.316		8.316										-13.350	-2.831	-16.181	-9.934	-2.107	-12.040
2029	7.313	14.487		14.487										-19.168	-2.633	-21.801	-13.847	-1.902	-15.749
2030	6.028	9.199		9.199										-13.057	-2.170	-15.227	-9.158	-1.522	-10.680
2031	4.534	2.749	0.013	2.762	24.831		24.831	9.733		9.733	1.132		1.132	2.950	-1.645	1.304	2.008	-1.120	0.888
2032	3.179	0.464	0.618	1.082	30.181		30.181	11.830		11.830	1.228		1.228	8.103	-1.763	6.340	5.357	-1.165	4.192
2033	2.111	0.050	4.278	4.328	33.991		33.991	13.323		13.323	1.297		1.297	10.624	-5.038	5.587	6.819	-3.233	3.586
2034	1.343	0.050	7.452	7.502	36.412		36.412	14.272		14.272	1.341		1.341	12.021	-7.935	4.086	7.491	-4.945	2.546
2035	0.827		4.731	4.731	37.687		37.687	14.771		14.771	1.363		1.363	12.879	-5.029	7.850	7.792	-3.043	4.749
2036	0.496		1.414		38.060	13.222	51.282	14.918	2.594	17.512	1.370	0.530	1.900	13.230	0.472	13.702	7.771	0.277	8.048
2037	0.291		0.239		37.754	14.071	51.825	14.798	2.761	17.559	1.365	0.538	1.902	13.247	1.880	15.127	7.554	1.072	8.626
2038	0.168		0.026		36.952	14.619	51.571	14.483	2.868	17.352	1.350	0.543	1.893	13.025	2.239	15.265	7.212	1.240	8.452
2039	0.096				35.801	14.957	50.758	14.032	2.935	16.967	1.330	0.546	1.875	12.641	2.354	14.996	6.795	1.266	8.061
2040	0.054				34.416	15.145	49.561	13.490	2.972	16.461	1.305	0.547	1.852	12.150	2.405	14.555	6.341	1.255	7.596
2041					32.886	15.225	48.111	12.890	2.987	15.877	1.277	0.548	1.825	11.612	2.439	14.052	5.884	1.236	7.120
2042					31.275	15.226	46.501	12.258	2.988	15.246	1.248	0.548	1.796	11.010	2.439	13.450	5.416	1.200	6.616
2043					29.633	15.168	44.801	11.615	2.976	14.591	1.218	0.548	1.766	10.396	2.429	12.825	4.965	1.160	6.125
2044					27.996	15.067	43.063	10.973	2.956	13.929	1.189	0.547	1.736	9.784	2.410	12.194	4.537	1.117	5.654
2045					26.390	14.932	41.322	10.343	2.930	13.273	1.160	0.545	1.706	9.183	2.384	11.568	4.134	1.073	5.208
2046					24.831	14.774	39.605	9.733	2.899	12.631	1.132	0.544	1.676	8.601	2.355	10.955	3.759	1.029	4.788
2047					23.333	14.598	37.930	9.145	2.864	12.010	1.105	0.542	1.648	8.040	2.322	10.362	3.412	0.985	4.397
2048					21.902	14.408	36.310	8.584	2.827	11.412	1.079	0.541	1.620	7.505	2.286	9.792	3.092	0.942	4.034
2049					20.543	14.210	34.753	8.052	2.788	10.840	1.055	0.539	1.594	6.997	2.249	9.246	2.799	0.900	3.698
2050					19.257	14.005	33.263	7.548	2.748	10.296	1.032	0.537	1.569	6.516	2.211	8.727	2.530	0.859	3.389
2051					18.045	13.797	31.842	7.073	2.707	9.780	1.010	0.535	1.545	6.063	2.172	8.235	2.286	0.819	3.105
2052					16.905	13.586	30.491	6.626	2.666	9.292	0.989	0.533	1.523	5.637	2.132	7.769	2.063	0.781	2.844
2053					15.835	13.374	29.209	6.207	2.624	8.831	0.970	0.531	1.502	5.237	2.093	7.329	1.861	0.744	2.605
2054					14.833	13.163	27.996	5.814	2.583	8.397	0.952	0.530	1.482	4.862	2.053	6.915	1.677	0.708	2.386
2055					13.895	12.953	26.848	5.446	2.542	7.988	0.935	0.528	1.463	4.511	2.014	6.525	1.511	0.675	2.186
2056					13.018	12.745	25.762	5.102	2.501	7.603	0.919	0.526	1.445	4.183	1.975	6.158	1.360	0.642	2.003
2057					12.199	12.539	24.737	4.781	2.460	7.242	0.905	0.524	1.429	3.877	1.936	5.813	1.224	0.611	1.835
2058					11.434	12.335	23.769	4.481	2.420	6.902	0.891	0.522	1.413	3.591	1.898	5.489	1.101	0.582	1.683
2059					10.720	12.135	22.855	4.202	2.381	6.583	0.878	0.520	1.398	3.324	1.861	5.184	0.989	0.554	1.543
2060					10.054	11.939	21.993	3.941	2.343	6.283	0.866	0.519	1.385	3.075	1.824	4.899	0.888	0.527	1.415
2061					9.432	11.746	21.178	3.697	2.305	6.002	0.855	0.517	1.372	2.842	1.788	4.630	0.797	0.502	1.299
2062					8.852	11.556	20.408	3.470	2.267	5.737	0.844	0.515	1.360	2.625	1.752	4.378	0.715	0.477	1.192
2063					8.311	11.370	19.681	3.258	2.231	5.489	0.835	0.513	1.348	2.423	1.718	4.141	0.641	0.454	1.095
2064					7.807	11.188	18.994	3.060	2.195	5.255	0.826	0.512	1.337	2.234	1.683	3.918	0.574	0.432	1.006
2065					7.335	11.009	18.345	2.875	2.160	5.035	0.817	0.510	1.327	2.058	1.650	3.708	0.513	0.411	0.924
2066					6.896	10.835	17.730	2.703	2.126	4.829	0.809	0.509	1.318	1.894	1.617	3.511	0.458	0.391	0.850
2067					6.485	10.664	17.149	2.542	2.092	4.634	0.802	0.507	1.309	1.740	1.585	3.325	0.409	0.372	0.781
2068					6.101	10.496	16.598	2.391	2.060	4.451	0.795	0.506	1.300	1.597	1.554	3.151	0.364	0.354	0.719
2069					5.743	10.333	16.076	2.251	2.027	4.278	0.788	0.504	1.293	1.463	1.523	2.986	0.324	0.337	0.661
2070					5.408	10.173	15.581	2.120	1.996	4.116	0.782	0.503	1.285	1.337	1.493	2.831	0.288	0.321	0.609

Appendix IV: The Resource Reserve and Price Sensitivity Analysis

calculated by using the model of Mohn (2018) - 33% and 16.5% increase in Price and Reserve respectively:

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.481**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**86**
	NOK/bbl		*778*
Gas price	*NOK/SM³*		**2.66**
	USD/MMBtu		*7.79*
	USD/boe		*43.28*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.44*
	NOK per boe		**40.00**
Total	*USD bn*		*6.58*
118	*NOK bn*		*59.24*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.660*
Oil field		*22%*	*36.496*
Gas field		*11%*	*18.772*
Exploration		*31%*	*50.840*
Operation		*36%*	*60.552*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploration	*Field development (NOK bn)*			*Extraction (1,000 boe per year)*			*Gross revenue (NOK bn)*			*Cost of operation (NOK bn)*			*Total cash flow (NOK bn)*			*Total DCF @3% (NOK bn)*		
		Oil field develop	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
Sum	**59**	**37**	**19**	**55**	**948**	**533**	**1,481**	**737**	**208**	**945**	**49**	**22**	**71**	**615**	**147**	**761**	**276**	**45**	**321**
2020																			
2021																			
2022																			
2023																			
2024	1.136																		
2025	3.312													-2.120	-1.192	-3.312	-1.724	-0.969	-2.693
2026	6.153	0.025		0.025										-3.963	-2.215	-6.178	-3.128	-1.749	-4.877
2027	8.385	1.202		1.202										-6.568	-3.019	-9.587	-5.034	-2.314	-7.348
2028	9.164	8.316		8.316										-14.181	-3.299	-17.481	-10.552	-2.455	-13.007
2029	8.522	14.487		14.487										-19.941	-3.068	-23.009	-14.406	-2.216	-16.622
2030	7.024	9.199		9.199										-13.694	-2.529	-16.223	-9.605	-1.774	-11.378
2031	5.284	2.749	0.013	2.762	28.934		28.934	22.512		22.512	1.319		1.319	15.062	-1.915	13.147	10.257	-1.304	8.953
2032	3.705	0.464	0.618	1.082	35.168		35.168	27.362		27.362	1.431		1.431	23.096	-1.952	21.145	15.269	-1.290	13.979
2033	2.460	0.050	4.278	4.328	39.607		39.607	30.816		30.816	1.511		1.511	27.680	-5.163	22.517	17.767	-3.314	14.453
2034	1.565	0.050	7.452	7.502	42.429		42.429	33.012		33.012	1.562		1.562	30.397	-8.015	22.382	18.943	-4.995	13.948
2035	0.963		4.731	4.731	43.913		43.913	34.167		34.167	1.589		1.589	31.961	-5.078	26.883	19.337	-3.072	16.265
2036	0.578		1.414		44.349	15.406	59.755	34.506	6.001	40.506	1.597	0.618	2.214	32.539	3.761	36.301	19.113	2.209	21.323
2037	0.339		0.239		43.992	16.396	60.388	34.228	6.387	40.615	1.590	0.627	2.217	32.421	5.399	37.820	18.489	3.079	21.568
2038	0.196		0.026		43.057	17.034	60.092	33.501	6.635	40.136	1.573	0.632	2.206	31.802	5.906	37.708	17.608	3.270	20.878
2039	0.112				41.716	17.428	59.144	32.458	6.788	39.246	1.549	0.636	2.185	30.837	6.112	36.949	16.576	3.286	19.862
2040	0.063				40.103	17.647	57.750	31.202	6.874	38.076	1.520	0.638	2.158	29.641	6.213	35.855	15.470	3.243	18.712
2041					38.319	17.741	56.060	29.814	6.910	36.725	1.488	0.639	2.127	28.326	6.272	34.598	14.353	3.178	17.530
2042					36.442	17.742	54.184	28.354	6.911	35.265	1.454	0.639	2.093	26.900	6.272	33.172	13.233	3.085	16.318
2043					34.529	17.674	52.203	26.865	6.884	33.750	1.420	0.638	2.058	25.446	6.246	31.692	12.153	2.983	15.136
2044					32.622	17.556	50.178	25.381	6.838	32.220	1.385	0.637	2.022	23.996	6.201	30.197	11.127	2.876	14.002
2045					30.750	17.399	48.149	23.925	6.777	30.702	1.352	0.636	1.987	22.573	6.142	28.715	10.162	2.765	12.927
2046					28.934	17.215	46.149	22.512	6.706	29.218	1.319	0.634	1.953	21.193	6.072	27.265	9.263	2.654	11.917
2047					27.188	17.009	44.197	21.154	6.626	27.779	1.288	0.632	1.920	19.866	5.993	25.859	8.430	2.543	10.973
2048					25.521	16.789	42.310	19.856	6.540	26.396	1.258	0.630	1.888	18.599	5.910	24.508	7.662	2.435	10.097
2049					23.937	16.558	40.495	18.624	6.450	25.074	1.229	0.628	1.857	17.395	5.822	23.217	6.958	2.329	9.286
2050					22.439	16.319	38.758	17.459	6.357	23.815	1.202	0.626	1.828	16.256	5.731	21.987	6.313	2.225	8.538
2051					21.026	16.076	37.103	16.360	6.262	22.622	1.177	0.624	1.800	15.183	5.638	20.821	5.724	2.126	7.850
2052					19.698	15.831	35.529	15.326	6.166	21.492	1.153	0.622	1.774	14.173	5.545	19.718	5.188	2.030	7.218
2053					18.452	15.584	34.036	14.356	6.070	20.427	1.130	0.619	1.750	13.226	5.451	18.677	4.700	1.937	6.637
2054					17.284	15.338	32.621	13.448	5.974	19.422	1.109	0.617	1.726	12.338	5.357	17.695	4.257	1.848	6.105
2055					16.191	15.093	31.284	12.597	5.879	18.476	1.090	0.615	1.705	11.507	5.264	16.772	3.855	1.763	5.618
2056					15.169	14.850	30.019	11.802	5.784	17.587	1.071	0.613	1.684	10.731	5.172	15.903	3.490	1.682	5.172
2057					14.214	14.610	28.825	11.059	5.691	16.750	1.054	0.611	1.665	10.005	5.080	15.086	3.159	1.604	4.763
2058					13.323	14.374	27.697	10.366	5.599	15.965	1.038	0.608	1.646	9.328	4.990	14.318	2.860	1.530	4.389
2059					12.491	14.141	26.632	9.719	5.508	15.227	1.023	0.606	1.629	8.696	4.902	13.597	2.588	1.459	4.047
2060					11.715	13.911	25.626	9.115	5.419	14.533	1.009	0.604	1.613	8.106	4.815	12.920	2.342	1.391	3.733
2061					10.991	13.686	24.677	8.551	5.331	13.882	0.996	0.602	1.598	7.555	4.729	12.284	2.120	1.327	3.446
2062					10.315	13.465	23.780	8.026	5.245	13.271	0.984	0.600	1.584	7.042	4.645	11.686	1.918	1.265	3.183
2063					9.685	13.249	22.933	7.535	5.161	12.696	0.973	0.598	1.571	6.563	4.562	11.125	1.735	1.206	2.942
2064					9.096	13.036	22.133	7.077	5.078	12.155	0.962	0.596	1.558	6.115	4.482	10.597	1.570	1.151	2.721
2065					8.547	12.828	21.376	6.650	4.997	11.647	0.952	0.594	1.547	5.698	4.402	10.101	1.420	1.097	2.518
2066					8.035	12.625	20.660	6.252	4.918	11.169	0.943	0.593	1.536	5.309	4.325	9.634	1.285	1.047	2.331
2067					7.557	12.426	19.982	5.879	4.840	10.719	0.934	0.591	1.525	4.945	4.249	9.194	1.162	0.998	2.160
2068					7.110	12.231	19.340	5.532	4.764	10.296	0.926	0.589	1.515	4.605	4.175	8.780	1.051	0.952	2.003
2069					6.692	12.040	18.732	5.207	4.690	9.897	0.919	0.587	1.506	4.288	4.102	8.390	0.950	0.909	1.858
2070					6.302	11.853	18.155	4.903	4.617	9.520	0.912	0.586	1.497	3.991	4.031	8.023	0.858	0.867	1.725

Appendix V: The Resource Reserve and Price Sensitivity Analysis

(Calculated by using the model of Mohn (2018) - 33% and 16.5% decrease in Price and Reserve respectively)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.061**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**44**
	NOK/bbl		*392*
Gas price	*NOK/SM³*		**1.34**
	USD/MMBtu		*3.93*
	USD/boe		*21.80*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.44*
	NOK per boe		**40.00**
Total	*USD bn*		*4.72*
85	*NOK bn*		*42.44*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.660*
Oil field		*22%*	*36.496*
Gas field		*11%*	*18.772*
Exploration		*31%*	*50.840*
Operation		*36%*	*60.552*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploration	Field development (NOK bn)			Extraction (1,000 boe per year)			Gross revenue (NOK bn)			Cost of operation (NOK bn)			Total cash flow (NOK bn)			Total DCF @3% (NOK bn)		
		Oil field develo	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
Sum	**42**	**37**	**19**	**55**	**679**	**382**	**1,061**	**266**	**75**	**341**	**35**	**15**	**51**	**168**	**26**	**194**	**66**	**1**	**66**
2020																			
2021																			
2022																			
2023																			
2024	0.814																		
2025	2.373													-1.519	-0.854	-2.373	-1.235	-0.695	-1.929
2026	4.408	0.025		0.025										-2.846	-1.587	-4.433	-2.247	-1.253	-3.500
2027	6.007	1.202		1.202										-5.046	-2.163	-7.209	-3.868	-1.658	-5.525
2028	6.565	8.316		8.316										-12.518	-2.364	-14.882	-9.315	-1.759	-11.073
2029	6.105	14.487		14.487										-18.394	-2.198	-20.592	-13.289	-1.588	-14.876
2030	5.032	9.199		9.199										-12.419	-1.812	-14.231	-8.711	-1.271	-9.981
2031	3.785	2.749	0.013	2.762	20.728		20.728	8.125		8.125	0.945		0.945	2.008	-1.376	0.632	1.367	-0.937	0.431
2032	2.654	0.464	0.618	1.082	25.195		25.195	9.875		9.875	1.025		1.025	6.687	-1.573	5.114	4.421	-1.040	3.381
2033	1.762	0.050	4.278	4.328	28.375		28.375	11.121		11.121	1.083		1.083	8.861	-4.912	3.949	5.687	-3.153	2.534
2034	1.121	0.050	7.452	7.502	30.396		30.396	11.914		11.914	1.119		1.119	10.027	-7.855	2.171	6.248	-4.895	1.353
2035	0.690		4.731	4.731	31.460		31.460	12.331		12.331	1.138		1.138	10.751	-4.980	5.771	6.504	-3.013	3.491
2036	0.414		1.414		31.772	11.037	42.809	12.453	2.165	14.618	1.144	0.443	1.586	11.044	0.160	11.204	6.487	0.094	6.581
2037	0.243		0.239		31.516	11.746	43.262	12.353	2.305	14.657	1.139	0.449	1.588	11.058	1.530	12.588	6.306	0.872	7.179
2038	0.141		0.026		30.847	12.203	43.050	12.090	2.394	14.485	1.127	0.453	1.580	10.873	1.865	12.738	6.020	1.032	7.053
2039	0.080				29.886	12.485	42.371	11.714	2.450	14.163	1.110	0.456	1.565	10.553	1.965	12.518	5.673	1.056	6.729
2040	0.045				28.730	12.643	41.373	11.261	2.480	13.741	1.089	0.457	1.546	10.143	2.007	12.150	5.293	1.048	6.341
2041					27.452	12.710	40.162	10.760	2.494	13.253	1.066	0.458	1.524	9.694	2.036	11.730	4.912	1.032	5.943
2042					26.107	12.710	38.818	10.233	2.494	12.727	1.042	0.458	1.499	9.191	2.036	11.227	4.521	1.002	5.523
2043					24.737	12.662	37.399	9.696	2.484	12.180	1.017	0.457	1.474	8.678	2.027	10.706	4.145	0.968	5.113
2044					23.370	12.577	35.948	9.160	2.468	11.628	0.993	0.456	1.449	8.167	2.011	10.179	3.787	0.933	4.720
2045					22.029	12.465	34.494	8.634	2.446	11.080	0.968	0.455	1.424	7.666	1.990	9.656	3.451	0.896	4.347
2046					20.728	12.333	33.061	8.125	2.420	10.544	0.945	0.454	1.399	7.180	1.966	9.145	3.138	0.859	3.997
2047					19.478	12.186	31.663	7.634	2.391	10.025	0.922	0.453	1.375	6.712	1.938	8.650	2.848	0.822	3.671
2048					18.283	12.028	30.311	7.166	2.360	9.526	0.901	0.451	1.352	6.265	1.908	8.174	2.581	0.786	3.367
2049					17.149	11.862	29.011	6.721	2.327	9.049	0.881	0.450	1.331	5.841	1.877	7.718	2.336	0.751	3.087
2050					16.075	11.691	27.767	6.301	2.294	8.595	0.861	0.448	1.310	5.440	1.845	7.285	2.112	0.717	2.829
2051					15.064	11.517	26.581	5.904	2.260	8.164	0.843	0.447	1.290	5.061	1.813	6.874	1.908	0.683	2.592
2052					14.112	11.341	25.453	5.531	2.225	7.756	0.826	0.445	1.271	4.705	1.780	6.485	1.722	0.652	2.374
2053					13.219	11.164	24.383	5.181	2.190	7.372	0.810	0.444	1.253	4.371	1.747	6.118	1.553	0.621	2.174
2054					12.382	10.988	23.370	4.853	2.156	7.009	0.795	0.442	1.237	4.058	1.714	5.772	1.400	0.591	1.992
2055					11.599	10.813	22.412	4.546	2.121	6.668	0.781	0.440	1.221	3.766	1.681	5.447	1.261	0.563	1.824
2056					10.867	10.639	21.506	4.259	2.087	6.347	0.767	0.439	1.206	3.492	1.648	5.140	1.136	0.536	1.672
2057					10.183	10.467	20.650	3.991	2.054	6.045	0.755	0.437	1.193	3.236	1.616	4.852	1.022	0.510	1.532
2058					9.545	10.297	19.842	3.741	2.020	5.761	0.744	0.436	1.180	2.997	1.584	4.582	0.919	0.486	1.405
2059					8.949	10.130	19.079	3.507	1.988	5.495	0.733	0.434	1.167	2.774	1.553	4.328	0.826	0.462	1.288
2060					8.393	9.966	18.359	3.289	1.955	5.245	0.723	0.433	1.156	2.567	1.522	4.089	0.742	0.440	1.182
2061					7.874	9.805	17.679	3.086	1.924	5.010	0.714	0.431	1.145	2.373	1.492	3.865	0.666	0.419	1.084
2062					7.390	9.647	17.036	2.896	1.893	4.789	0.705	0.430	1.135	2.192	1.463	3.654	0.597	0.398	0.995
2063					6.938	9.491	16.430	2.719	1.862	4.582	0.697	0.429	1.125	2.023	1.434	3.456	0.535	0.379	0.914
2064					6.517	9.339	15.856	2.554	1.832	4.387	0.689	0.427	1.116	1.865	1.405	3.270	0.479	0.361	0.840
2065					6.123	9.190	15.314	2.400	1.803	4.203	0.682	0.426	1.108	1.718	1.377	3.095	0.428	0.343	0.772
2066					5.756	9.044	14.801	2.256	1.775	4.031	0.676	0.425	1.100	1.581	1.350	2.931	0.383	0.327	0.709
2067					5.414	8.902	14.315	2.122	1.747	3.868	0.669	0.423	1.093	1.453	1.323	2.776	0.341	0.311	0.652
2068					5.093	8.762	13.855	1.996	1.719	3.715	0.664	0.422	1.086	1.333	1.297	2.630	0.304	0.296	0.600
2069					4.794	8.625	13.420	1.879	1.692	3.571	0.658	0.421	1.079	1.221	1.272	2.492	0.270	0.282	0.552
2070					4.515	8.492	13.006	1.770	1.666	3.436	0.653	0.420	1.073	1.116	1.246	2.363	0.240	0.268	0.508

Appendix VI: The Costs and Price Sensitivity Analysis

(Calculated by using the model of Mohn (2018) - 0.03% and 33% increase in Costs and Price respectively)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.271**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**86**
	NOK/bbl		*778*
Gas price	*NOK/SM³*		**2.66**
	USD/MMBtu		*7.79*
	USD/boe		*43.28*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.45*
	NOK per boe		**40.01**
Total	*USD bn*		*5.65*
102	*NOK bn*		*50.86*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.710*
Oil field		*22%*	*36.507*
Gas field		*11%*	*18.778*
Exploration		*31%*	*50.855*
Operation		*36%*	*60.570*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploration	*Field development (NOK bn)*			*Extraction (1,000 boe per year)*			*Gross revenue (NOK bn)*			*Cost of operation (NOK bn)*			*Total cash flow (NOK bn)*			*Total DCF @3% (NOK bn)*		
		Oil field develo	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
Sum	**51**	**37**	**19**	**55**	**813**	**458**	**1,271**	**633**	**178**	**811**	**42**	**19**	**61**	**523**	**123**	**646**	**233**	**37**	**270**
2020																			
2021																			
2022																			
2023																			
2024	0.975																		
2025	2.843													-1.820	-1.024	-2.843	-1.480	-0.832	-2.312
2026	5.282	0.025		0.025										-3.406	-1.902	-5.307	-2.688	-1.501	-4.190
2027	7.199	1.202		1.202										-5.809	-2.591	-8.401	-4.452	-1.986	-6.438
2028	7.867	8.319		8.319										-13.354	-2.832	-16.186	-9.936	-2.107	-12.044
2029	7.316	14.492		14.492										-19.174	-2.634	-21.807	-13.851	-1.903	-15.754
2030	6.030	9.201		9.201										-13.061	-2.171	-15.232	-9.161	-1.523	-10.683
2031	4.536	2.750	0.013	2.763	24.831		24.831	19.320		19.320	1.132		1.132	12.535	-1.646	10.889	8.536	-1.121	7.415
2032	3.180	0.464	0.618	1.082	30.181		30.181	23.483		23.483	1.228		1.228	19.755	-1.763	17.992	13.060	-1.166	11.895
2033	2.112	0.050	4.279	4.329	33.991		33.991	26.446		26.446	1.297		1.297	23.748	-5.039	18.709	15.243	-3.234	12.008
2034	1.344	0.050	7.454	7.504	36.412		36.412	28.331		28.331	1.341		1.341	26.080	-7.938	18.142	16.252	-4.947	11.305
2035	0.827		4.733	4.733	37.687		37.687	29.322		29.322	1.363		1.363	27.429	-5.031	22.399	16.595	-3.044	13.551
2036	0.496		1.414		38.060	13.222	51.282	29.613	5.150	34.763	1.370	0.530	1.900	27.925	3.027	30.952	16.403	1.778	18.181
2037	0.291		0.239		37.754	14.071	51.825	29.375	5.481	34.856	1.365	0.538	1.902	27.823	4.600	32.423	15.867	2.623	18.490
2038	0.168		0.026		36.952	14.619	51.571	28.751	5.694	34.445	1.350	0.543	1.893	27.293	5.065	32.358	15.111	2.804	17.916
2039	0.096				35.801	14.957	50.758	27.855	5.826	33.681	1.330	0.546	1.875	26.464	5.246	31.710	14.226	2.820	17.045
2040	0.054				34.416	15.145	49.561	26.778	5.899	32.677	1.305	0.547	1.852	25.438	5.332	30.771	13.276	2.783	16.059
2041					32.886	15.225	48.111	25.587	5.931	31.517	1.277	0.548	1.825	24.310	5.382	29.692	12.317	2.727	15.045
2042					31.275	15.226	46.501	24.333	5.931	30.264	1.248	0.548	1.796	23.085	5.383	28.468	11.356	2.648	14.004
2043					29.633	15.168	44.801	23.056	5.908	28.964	1.218	0.548	1.766	21.837	5.361	27.198	10.430	2.560	12.990
2044					27.996	15.067	43.063	21.782	5.869	27.651	1.189	0.547	1.736	20.593	5.322	25.915	9.549	2.468	12.017
2045					26.390	14.932	41.322	20.532	5.816	26.349	1.160	0.545	1.706	19.372	5.271	24.643	8.721	2.373	11.094
2046					24.831	14.774	39.605	19.320	5.755	25.075	1.132	0.544	1.676	18.188	5.211	23.399	7.949	2.277	10.227
2047					23.333	14.598	37.930	18.154	5.686	23.840	1.105	0.542	1.648	17.049	5.144	22.193	7.235	2.183	9.417
2048					21.902	14.408	36.310	17.041	5.612	22.653	1.079	0.541	1.620	15.962	5.072	21.033	6.576	2.089	8.665
2049					20.543	14.210	34.753	15.983	5.535	21.518	1.055	0.539	1.594	14.929	4.996	19.925	5.971	1.998	7.970
2050					19.257	14.005	33.263	14.983	5.455	20.438	1.032	0.537	1.569	13.951	4.918	18.870	5.418	1.910	7.328
2051					18.045	13.797	31.842	14.040	5.374	19.414	1.010	0.535	1.545	13.030	4.839	17.869	4.913	1.824	6.737
2052					16.905	13.586	30.491	13.153	5.292	18.445	0.989	0.533	1.523	12.164	4.759	16.922	4.452	1.742	6.194
2053					15.835	13.374	29.209	12.321	5.210	17.530	0.970	0.531	1.502	11.350	4.678	16.029	4.034	1.663	5.696
2054					14.833	13.163	27.996	11.541	5.127	16.668	0.952	0.530	1.482	10.589	4.598	15.186	3.653	1.586	5.240
2055					13.895	12.953	26.848	10.811	5.045	15.856	0.935	0.528	1.463	9.876	4.518	14.393	3.308	1.513	4.822
2056					13.018	12.745	25.762	10.129	4.964	15.093	0.919	0.526	1.445	9.209	4.438	13.648	2.995	1.443	4.439
2057					12.199	12.539	24.737	9.491	4.884	14.375	0.905	0.524	1.429	8.587	4.360	12.947	2.711	1.377	4.088
2058					11.434	12.335	23.769	8.896	4.805	13.701	0.891	0.522	1.413	8.005	4.283	12.288	2.454	1.313	3.767
2059					10.720	12.135	22.855	8.341	4.727	13.068	0.878	0.520	1.398	7.463	4.207	11.669	2.221	1.252	3.473
2060					10.054	11.939	21.993	7.822	4.650	12.473	0.866	0.519	1.385	6.956	4.132	11.088	2.010	1.194	3.204
2061					9.432	11.746	21.178	7.339	4.575	11.914	0.855	0.517	1.372	6.484	4.058	10.542	1.819	1.139	2.958
2062					8.852	11.556	20.408	6.888	4.501	11.389	0.844	0.515	1.360	6.043	3.986	10.029	1.646	1.086	2.732
2063					8.311	11.370	19.681	6.467	4.429	10.896	0.835	0.513	1.348	5.632	3.915	9.547	1.489	1.035	2.525
2064					7.807	11.188	18.994	6.074	4.358	10.432	0.826	0.512	1.337	5.248	3.846	9.094	1.347	0.987	2.335
2065					7.335	11.009	18.345	5.707	4.288	9.996	0.817	0.510	1.327	4.890	3.778	8.668	1.219	0.942	2.161
2066					6.896	10.835	17.730	5.365	4.220	9.585	0.809	0.509	1.318	4.556	3.712	8.268	1.103	0.898	2.001
2067					6.485	10.664	17.149	5.046	4.154	9.199	0.802	0.507	1.309	4.244	3.647	7.890	0.997	0.857	1.854
2068					6.101	10.496	16.598	4.747	4.089	8.836	0.795	0.506	1.300	3.952	3.583	7.535	0.902	0.817	1.719
2069					5.743	10.333	16.076	4.468	4.025	8.493	0.788	0.504	1.293	3.680	3.521	7.201	0.815	0.780	1.595
2070					5.408	10.173	15.581	4.208	3.962	8.170	0.782	0.503	1.285	3.425	3.460	6.885	0.737	0.744	1.480

Appendix VII: The Costs and Price Sensitivity Analysis

(Calculated by using the model of Mohn (2018) - 0.03% and 33% decrease in Costs and Price respectively)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions				Year	Exploration	Field development (NOK bn)			Extraction (1,000 boe per year)			Gross revenue (NOK bn)			Cost of operation (NOK bn)			Total cash flow (NOK bn)			Total DCF @3% (NOK bn)		
						Oil field develo	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
	Unit			Sum	51	37	19	55	813	458	1,271	319	90	409	42	19	61	208	35	243	84	3	87
Resource est	*Bn boe*		1.271	2020																			
Oil	*Per cent*		64%	2021																			
Gas	*Per cent*		36%	2022																			
Oil price	*USD/bbl*		44	2023																			
	NOK/bbl		*392*	2024	0.975																		
Gas price	*NOK/SM^3*		1.34	2025	2.842													-1.819	-1.023	-2.842	-1.479	-0.832	-2.310
	USD/MMBtu		*3.93*	2026	5.279	0.025		0.025										-3.404	-1.900	-5.304	-2.687	-1.500	-4.187
	USD/boe		*21.80*	2027	7.194	1.201		1.201										-5.806	-2.590	-8.395	-4.449	-1.985	-6.434
Exchange rate	*NOK/USD*		9.00	2028	7.862	8.314		8.314										-13.346	-2.830	-16.176	-9.931	-2.106	-12.037
				2029	7.311	14.483		14.483										-19.162	-2.632	-21.794	-13.843	-1.901	-15.745
Extraction; ramp-up and decline				2030	6.026	9.196		9.196										-13.053	-2.170	-15.222	-9.155	-1.522	-10.677
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*	2031	4.533	2.748	0.013	2.761	24.831		24.831	9.733		9.733	1.132		1.132	2.951	-1.645	1.306	2.010	-1.120	0.890
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*	2032	3.178	0.464	0.618	1.081	30.181		30.181	11.830		11.830	1.228		1.228	8.103	-1.762	6.341	5.357	-1.165	4.192
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*	2033	2.110	0.050	4.276	4.327	33.991		33.991	13.323		13.323	1.297		1.297	10.625	-5.036	5.589	6.820	-3.232	3.587
				2034	1.343	0.050	7.449	7.500	36.412		36.412	14.272		14.272	1.341		1.341	12.021	-7.933	4.089	7.491	-4.943	2.548
Government take			85%	2035	0.827		4.730	4.730	37.687		37.687	14.771		14.771	1.363		1.363	12.879	-5.027	7.851	7.792	-3.042	4.750
				2036	0.496		1.413		38.060	13.222	51.282	14.918	2.594	17.512	1.370	0.530	1.900	13.230	0.472	13.702	7.771	0.277	8.049
Discount rates			6.3 %	2037	0.291		0.238		37.754	14.071	51.825	14.798	2.761	17.558	1.365	0.538	1.902	13.247	1.880	15.126	7.554	1.072	8.626
Oil	*Per cent*		7%	2038	0.168		0.026		36.952	14.619	51.571	14.483	2.868	17.352	1.350	0.543	1.893	13.025	2.239	15.264	7.212	1.240	8.452
Gas	*Per cent*		5%	2039	0.096				35.801	14.957	50.758	14.032	2.934	16.967	1.330	0.546	1.875	12.641	2.354	14.995	6.795	1.265	8.061
Govt	*Per cent*		3%	2040	0.054				34.416	15.145	49.561	13.490	2.971	16.461	1.305	0.547	1.852	12.150	2.404	14.555	6.341	1.255	7.596
Extra years	*Base year: 2018*		2	2041					32.886	15.225	48.111	12.890	2.987	15.877	1.277	0.548	1.825	11.612	2.439	14.052	5.884	1.236	7.120
Exploration cost				2042					31.275	15.226	46.501	12.258	2.987	15.245	1.248	0.548	1.796	11.010	2.439	13.449	5.416	1.200	6.616
Drillout cost	*USD per boe*		*4.44*	2043					29.633	15.168	44.801	11.615	2.976	14.591	1.218	0.548	1.766	10.396	2.428	12.825	4.965	1.160	6.125
	NOK per boe		39.99	2044					27.996	15.067	43.063	10.973	2.956	13.929	1.189	0.547	1.736	9.784	2.409	12.193	4.537	1.117	5.654
Total	*USD bn*		*5.65*	2045					26.390	14.932	41.322	10.343	2.930	13.273	1.160	0.545	1.706	9.183	2.384	11.568	4.134	1.073	5.208
102	*NOK bn*		*50.82*	2046					24.831	14.774	39.605	9.733	2.899	12.631	1.132	0.544	1.676	8.601	2.355	10.955	3.759	1.029	4.788
				2047					23.333	14.598	37.930	9.145	2.864	12.009	1.105	0.542	1.648	8.040	2.322	10.362	3.412	0.985	4.397
Capex per unit of extraction capacity				2048					21.902	14.408	36.310	8.584	2.827	11.411	1.079	0.541	1.620	7.505	2.286	9.791	3.092	0.942	4.034
Oil	*NOK/(bbl/day)*		350,000	2049					20.543	14.210	34.753	8.052	2.788	10.840	1.055	0.539	1.594	6.997	2.249	9.246	2.799	0.900	3.698
Gas	*NOK/(boe/day)*		450,000	2050					19.257	14.005	33.263	7.548	2.748	10.296	1.032	0.537	1.569	6.516	2.211	8.727	2.530	0.858	3.389
				2051					18.045	13.797	31.842	7.073	2.707	9.780	1.010	0.535	1.545	6.063	2.172	8.234	2.286	0.819	3.105
Expenditures		*100%*	*166.613*	2052					16.905	13.586	30.491	6.626	2.666	9.291	0.989	0.533	1.523	5.637	2.132	7.769	2.063	0.780	2.844
Oil field		*22%*	*36.485*	2053					15.835	13.374	29.209	6.207	2.624	8.831	0.970	0.531	1.502	5.237	2.093	7.329	1.861	0.744	2.605
Gas field		*11%*	*18.766*	2054					14.833	13.163	27.996	5.814	2.583	8.396	0.952	0.530	1.482	4.862	2.053	6.915	1.677	0.708	2.386
Exploration		*31%*	*50.828*	2055					13.895	12.953	26.848	5.446	2.541	7.987	0.935	0.528	1.463	4.511	2.014	6.525	1.511	0.675	2.186
Operation		*36%*	*60.534*	2056					13.018	12.745	25.762	5.102	2.500	7.603	0.919	0.526	1.445	4.183	1.975	6.158	1.360	0.642	2.003
				2057					12.199	12.539	24.737	4.781	2.460	7.241	0.905	0.524	1.429	3.877	1.936	5.813	1.224	0.611	1.835
Cost function coefficients				2058					11.434	12.335	23.769	4.481	2.420	6.902	0.891	0.522	1.413	3.591	1.898	5.489	1.101	0.582	1.683
Oil fixed	*Koeffisient*		*2.00*	2059					10.720	12.135	22.855	4.202	2.381	6.583	0.878	0.520	1.398	3.324	1.861	5.184	0.989	0.554	1.543
Oil variable	*Koeffisient*		*2.00*	2060					10.054	11.939	21.993	3.941	2.342	6.283	0.866	0.519	1.385	3.075	1.824	4.898	0.888	0.527	1.415
Gas fixed	*Koeffisient*		*3.00*	2061					9.432	11.746	21.178	3.697	2.304	6.001	0.855	0.517	1.372	2.842	1.788	4.630	0.797	0.502	1.299
Gas variable	*Koeffisient*		1.00	2062					8.852	11.556	20.408	3.470	2.267	5.737	0.844	0.515	1.360	2.625	1.752	4.377	0.715	0.477	1.192
				2063					8.311	11.370	19.681	3.258	2.231	5.488	0.835	0.513	1.348	2.423	1.717	4.140	0.641	0.454	1.095
	Min olje		4.00	2064					7.807	11.188	18.994	3.060	2.195	5.255	0.826	0.512	1.337	2.234	1.683	3.917	0.574	0.432	1.006
	Min gass		4.00	2065					7.335	11.009	18.345	2.875	2.160	5.035	0.817	0.510	1.327	2.058	1.650	3.708	0.513	0.411	0.924
				2066					6.896	10.835	17.730	2.703	2.126	4.829	0.809	0.509	1.318	1.894	1.617	3.511	0.458	0.391	0.850
				2067					6.485	10.664	17.149	2.542	2.092	4.634	0.802	0.507	1.309	1.740	1.585	3.325	0.409	0.372	0.781
				2068					6.101	10.496	16.598	2.391	2.059	4.451	0.795	0.506	1.300	1.597	1.554	3.150	0.364	0.354	0.719
				2069					5.743	10.333	16.076	2.251	2.027	4.278	0.788	0.504	1.293	1.463	1.523	2.986	0.324	0.337	0.661
Unit cost of production (opex)				2070					5.408	10.173	15.581	2.120	1.996	4.116	0.782	0.503	1.285	1.337	1.493	2.831	0.288	0.321	0.609

Appendix VIII: The Combined Sensitivity Analysis

(Calculated by using the model of Mohn (2018) - 33%, 16.5% and 0.3% increase in Price, Reserve and Costs respectively)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions	Unit		
Resource est	*Bn boe*		**1.481**
Oil	*Per cent*		**64%**
Gas	*Per cent*		36%
Oil price	*USD/bbl*		**86**
	NOK/bbl		*778*
Gas price	*NOK/SM³*		**2.66**
	USD/MMBtu		*7.79*
	USD/boe		*43.28*
Exchange rate	*NOK/USD*		**9.00**
Extraction; ramp-up and decline			
Ramp-up oil	*Per cent per year (2 yrs)*		*8.9 %*
Decline oil	*Per cent per year (yr 8 ->)*		*-5.6 %*
Decline gas	*Per cent per year (yr 8 ->)*		*-0.9 %*
Government take			**85%**
Discount rates			6.3 %
Oil	*Per cent*		7%
Gas	*Per cent*		5%
Govt	*Per cent*		3%
Extra years	*Base year: 2018*		2
Exploration cost			
Drillout cost	*USD per boe*		*4.45*
	NOK per boe		**40.01**
Total	*USD bn*		*6.58*
119	*NOK bn*		*59.26*
Capex per unit of extraction capacity			
Oil	*NOK/(bbl/day)*		**350,000**
Gas	*NOK/(boe/day)*		**450,000**
Expenditures		*100%*	*166.710*
Oil field		*22%*	*36.507*
Gas field		*11%*	*18.778*
Exploration		*31%*	*50.855*
Operation		*36%*	*60.570*
Cost function coefficients			
Oil fixed	*Koeffisient*		*2.00*
Oil variable	*Koeffisient*		*2.00*
Gas fixed	*Koeffisient*		*3.00*
Gas variable	*Koeffisient*		1.00
	Min olje		4.00
	Min gass		4.00
Unit cost of production (opex)			

Year	Exploratior	*Field development (NOK bn)*			*Extraction (1,000 boe per year)*			*Gross revenue (NOK bn)*			*Cost of operation (NOK bn)*			*Total cash flow (NOK bn)*			*Total DCF @3% (NOK bn)*		
		Oil field develop	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
Sum	**59**	**37**	**19**	**55**	**948**	**533**	**1,481**	**737**	**208**	**945**	**49**	**22**	**71**	**615**	**147**	**761**	**276**	**45**	**321**
2020																			
2021																			
2022																			
2023																			
2024	1.137																		
2025	3.313													-2.120	-1.193	-3.313	-1.724	-0.970	-2.694
2026	6.155	0.025		0.025										-3.964	-2.216	-6.180	-3.129	-1.749	-4.879
2027	8.388	1.202		1.202										-6.570	-3.020	-9.590	-5.036	-2.314	-7.350
2028	9.167	8.319		8.319										-14.186	-3.300	-17.486	-10.555	-2.456	-13.011
2029	8.524	14.492		14.492										-19.947	-3.069	-23.016	-14.410	-2.217	-16.627
2030	7.026	9.201		9.201										-13.698	-2.530	-16.228	-9.608	-1.774	-11.382
2031	5.285	2.750	0.013	2.763	28.934		28.934	22.512		22.512	1.319		1.319	15.061	-1.916	13.145	10.256	-1.304	8.951
2032	3.706	0.464	0.618	1.082	35.168		35.168	27.362		27.362	1.431		1.431	23.096	-1.952	21.143	15.269	-1.291	13.978
2033	2.461	0.050	4.279	4.329	39.607		39.607	30.816		30.816	1.511		1.511	27.680	-5.165	22.515	17.767	-3.315	14.451
2034	1.566	0.050	7.454	7.504	42.429		42.429	33.012		33.012	1.562		1.562	30.397	-8.018	22.379	18.942	-4.996	13.946
2035	0.964		4.733	4.733	43.913		43.913	34.167		34.167	1.589		1.589	31.961	-5.080	26.881	19.337	-3.073	16.264
2036	0.578		1.414		44.349	15.406	59.755	34.506	6.001	40.506	1.597	0.618	2.214	32.539	3.761	36.300	19.113	2.209	21.322
2037	0.340		0.239		43.992	16.396	60.388	34.228	6.387	40.615	1.590	0.627	2.217	32.421	5.399	37.820	18.489	3.079	21.568
2038	0.196		0.026		43.057	17.034	60.092	33.501	6.635	40.136	1.573	0.632	2.206	31.802	5.906	37.708	17.608	3.270	20.878
2039	0.112				41.716	17.428	59.144	32.458	6.788	39.246	1.549	0.636	2.185	30.837	6.112	36.949	16.576	3.286	19.862
2040	0.063				40.103	17.647	57.750	31.202	6.874	38.076	1.520	0.638	2.158	29.641	6.213	35.855	15.470	3.243	18.712
2041					38.319	17.741	56.060	29.814	6.910	36.725	1.488	0.639	2.127	28.326	6.272	34.598	14.353	3.178	17.530
2042					36.442	17.742	54.184	28.354	6.911	35.265	1.454	0.639	2.093	26.900	6.272	33.172	13.233	3.085	16.318
2043					34.529	17.674	52.203	26.865	6.884	33.750	1.420	0.638	2.058	25.446	6.246	31.692	12.153	2.983	15.136
2044					32.622	17.556	50.178	25.381	6.838	32.220	1.385	0.637	2.022	23.996	6.201	30.197	11.127	2.876	14.002
2045					30.750	17.399	48.149	23.925	6.777	30.702	1.352	0.636	1.987	22.573	6.142	28.715	10.162	2.765	12.927
2046					28.934	17.215	46.149	22.512	6.706	29.218	1.319	0.634	1.953	21.193	6.072	27.265	9.263	2.654	11.917
2047					27.188	17.009	44.197	21.154	6.626	27.779	1.288	0.632	1.920	19.866	5.993	25.859	8.430	2.543	10.973
2048					25.521	16.789	42.310	19.856	6.540	26.396	1.258	0.630	1.888	18.599	5.910	24.508	7.662	2.435	10.097
2049					23.937	16.558	40.495	18.624	6.450	25.074	1.229	0.628	1.857	17.395	5.822	23.217	6.958	2.329	9.286
2050					22.439	16.319	38.758	17.459	6.357	23.815	1.202	0.626	1.828	16.256	5.731	21.987	6.313	2.225	8.538
2051					21.026	16.076	37.103	16.360	6.262	22.622	1.177	0.624	1.800	15.183	5.638	20.821	5.724	2.126	7.850
2052					19.698	15.831	35.529	15.326	6.166	21.492	1.153	0.622	1.774	14.173	5.545	19.718	5.188	2.030	7.218
2053					18.452	15.584	34.036	14.356	6.070	20.427	1.130	0.619	1.750	13.226	5.451	18.677	4.700	1.937	6.637
2054					17.284	15.338	32.621	13.448	5.974	19.422	1.109	0.617	1.726	12.338	5.357	17.695	4.257	1.848	6.105
2055					16.191	15.093	31.284	12.597	5.879	18.476	1.090	0.615	1.705	11.507	5.264	16.772	3.855	1.763	5.618
2056					15.169	14.850	30.019	11.802	5.784	17.587	1.071	0.613	1.684	10.731	5.172	15.903	3.490	1.682	5.172
2057					14.214	14.610	28.825	11.059	5.691	16.750	1.054	0.611	1.665	10.005	5.080	15.086	3.159	1.604	4.763
2058					13.323	14.374	27.697	10.366	5.599	15.965	1.038	0.608	1.646	9.328	4.990	14.318	2.860	1.530	4.389
2059					12.491	14.141	26.632	9.719	5.508	15.227	1.023	0.606	1.629	8.696	4.902	13.597	2.588	1.459	4.047
2060					11.715	13.911	25.626	9.115	5.419	14.533	1.009	0.604	1.613	8.106	4.815	12.920	2.342	1.391	3.733
2061					10.991	13.686	24.677	8.551	5.331	13.882	0.996	0.602	1.598	7.555	4.729	12.284	2.120	1.327	3.446
2062					10.315	13.465	23.780	8.026	5.245	13.271	0.984	0.600	1.584	7.042	4.645	11.686	1.918	1.265	3.183
2063					9.685	13.249	22.933	7.535	5.161	12.696	0.973	0.598	1.571	6.563	4.562	11.125	1.735	1.206	2.942
2064					9.096	13.036	22.133	7.077	5.078	12.155	0.962	0.596	1.558	6.115	4.482	10.597	1.570	1.151	2.721
2065					8.547	12.828	21.376	6.650	4.997	11.647	0.952	0.594	1.547	5.698	4.402	10.101	1.420	1.097	2.518
2066					8.035	12.625	20.660	6.252	4.918	11.169	0.943	0.593	1.536	5.309	4.325	9.634	1.285	1.047	2.331
2067					7.557	12.426	19.982	5.879	4.840	10.719	0.934	0.591	1.525	4.945	4.249	9.194	1.162	0.998	2.160
2068					7.110	12.231	19.340	5.532	4.764	10.296	0.926	0.589	1.515	4.605	4.175	8.780	1.051	0.952	2.003
2069					6.692	12.040	18.732	5.207	4.690	9.897	0.919	0.587	1.506	4.288	4.102	8.390	0.950	0.909	1.858
2070					6.302	11.853	18.155	4.903	4.617	9.520	0.912	0.586	1.497	3.991	4.031	8.023	0.858	0.867	1.725

Appendix IX: The Combined Sensitivity Analysis

(Calculated by using the model of Mohn (2018) - 33%, 16.5% and 0.3% decrease in Price, Reserve and Costs respectively.)

DCF analysis: Lofoten oil and gas exploration 1.000

Assumptions			Year	Exploration	Field development (NOK bn)			Extraction (1,000 boe per year)			Gross revenue (NOK bn)			Cost of operation (NOK bn)			Total cash flow (NOK bn)			Total DCF @3% (NOK bn)		
					Oil field develop	ld develo	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	Total	Oil	Gas	tal cash flo	Oil	Gas	scounted ca
	Unit		**Sum**	**42**	**37**	**19**	**55**	**679**	**382**	**1,061**	**266**	**75**	**341**	**35**	**15**	**51**	**168**	**26**	**194**	**66**	**1**	**66**
Resource est	*Bn boe*	**1.061**	2020																			
Oil	*Per cent*	**64%**	2021																			
Gas	*Per cent*	36%	2022																			
Oil price	*USD/bbl*	**44**	2023																			
	NOK/bbl	*392*	2024	0.814																		
Gas price	*NOK/SM^3*	**1.34**	2025	2.372													-1.518	-0.854	-2.372	-1.234	-0.694	-1.929
	USD/MMBtu	*3.93*	2026	4.407	0.025		0.025										-2.845	-1.586	-4.432	-2.246	-1.252	-3.499
	USD/boe	*21.80*	2027	6.006	1.201		1.201										-5.045	-2.162	-7.207	-3.866	-1.657	-5.523
Exchange rate	*NOK/USD*	**9.00**	2028	6.563	8.314		8.314										-12.514	-2.363	-14.877	-9.312	-1.758	-11.070
			2029	6.103	14.483		14.483										-18.389	-2.197	-20.586	-13.285	-1.587	-14.872
Extraction; ramp-up and decline			2030	5.031	9.196		9.196										-12.416	-1.811	-14.227	-8.708	-1.270	-9.978
Ramp-up oil	*Per cent per year (2 yrs)*	*8.9 %*	2031	3.784	2.748	0.013	2.761	20.728		20.728	8.125		8.125	0.945		0.945	2.010	-1.375	0.634	1.368	-0.936	0.432
Decline oil	*Per cent per year (yr 8 ->)*	*-5.6 %*	2032	2.653	0.464	0.618	1.081	25.195		25.195	9.875		9.875	1.025		1.025	6.688	-1.573	5.115	4.422	-1.040	3.382
Decline gas	*Per cent per year (yr 8 ->)*	*-0.9 %*	2033	1.762	0.050	4.276	4.327	28.375		28.375	11.121		11.121	1.083		1.083	8.861	-4.910	3.950	5.687	-3.152	2.536
			2034	1.121	0.050	7.449	7.500	30.396		30.396	11.914		11.914	1.119		1.119	10.027	-7.853	2.174	6.248	-4.894	1.355
Government take		**85%**	2035	0.690		4.730	4.730	31.460		31.460	12.331		12.331	1.138		1.138	10.751	-4.978	5.773	6.504	-3.012	3.492
			2036	0.414		1.413		31.772	11.037	42.809	12.453	2.165	14.618	1.144	0.443	1.586	11.044	0.161	11.205	6.487	0.094	6.582
Discount rates		6.3 %	2037	0.243		0.238		31.516	11.746	43.262	12.353	2.305	14.657	1.139	0.449	1.588	11.058	1.530	12.588	6.306	0.872	7.179
Oil	*Per cent*	7%	2038	0.141		0.026		30.847	12.203	43.050	12.090	2.394	14.485	1.127	0.453	1.580	10.873	1.865	12.738	6.020	1.032	7.053
Gas	*Per cent*	5%	2039	0.080				29.886	12.485	42.371	11.714	2.450	14.163	1.110	0.456	1.565	10.553	1.965	12.518	5.673	1.056	6.729
Govt	*Per cent*	3%	2040	0.045				28.730	12.643	41.373	11.261	2.480	13.741	1.089	0.457	1.546	10.143	2.007	12.150	5.293	1.048	6.341
Extra years	*Base year: 2018*	2	2041					27.452	12.710	40.162	10.760	2.494	13.253	1.066	0.458	1.524	9.694	2.036	11.730	4.912	1.032	5.943
Exploration cost			2042					26.107	12.710	38.818	10.233	2.494	12.727	1.042	0.458	1.499	9.191	2.036	11.227	4.521	1.002	5.523
Drillout cost	*USD per boe*	*4.44*	2043					24.737	12.662	37.399	9.696	2.484	12.180	1.017	0.457	1.474	8.678	2.027	10.706	4.145	0.968	5.113
	NOK per boe	**39.99**	2044					23.370	12.577	35.948	9.160	2.468	11.628	0.993	0.456	1.449	8.167	2.011	10.179	3.787	0.933	4.720
Total	*USD bn*	*4.71*	2045					22.029	12.465	34.494	8.634	2.446	11.080	0.968	0.455	1.424	7.666	1.990	9.656	3.451	0.896	4.347
85	*NOK bn*	*42.43*	2046					20.728	12.333	33.061	8.125	2.420	10.544	0.945	0.454	1.399	7.180	1.966	9.145	3.138	0.859	3.997
			2047					19.478	12.186	31.663	7.634	2.391	10.025	0.922	0.453	1.375	6.712	1.938	8.650	2.848	0.822	3.671
Capex per unit of extraction capacity			2048					18.283	12.028	30.311	7.166	2.360	9.526	0.901	0.451	1.352	6.265	1.908	8.174	2.581	0.786	3.367
Oil	*NOK/(bbl/day)*	**350,000**	2049					17.149	11.862	29.011	6.721	2.327	9.049	0.881	0.450	1.331	5.841	1.877	7.718	2.336	0.751	3.087
Gas	*NOK/(boe/day)*	**450,000**	2050					16.075	11.691	27.767	6.301	2.294	8.595	0.861	0.448	1.310	5.440	1.845	7.285	2.112	0.717	2.829
			2051					15.064	11.517	26.581	5.904	2.260	8.164	0.843	0.447	1.290	5.061	1.813	6.874	1.908	0.683	2.592
Expenditures	*100%*	*166.613*	2052					14.112	11.341	25.453	5.531	2.225	7.756	0.826	0.445	1.271	4.705	1.780	6.485	1.722	0.652	2.374
Oil field	*22%*	*36.485*	2053					13.219	11.164	24.383	5.181	2.190	7.372	0.810	0.444	1.253	4.371	1.747	6.118	1.553	0.621	2.174
Gas field	*11%*	*18.766*	2054					12.382	10.988	23.370	4.853	2.156	7.009	0.795	0.442	1.237	4.058	1.714	5.772	1.400	0.591	1.992
Exploration	*31%*	*50.828*	2055					11.599	10.813	22.412	4.546	2.121	6.668	0.781	0.440	1.221	3.766	1.681	5.447	1.261	0.563	1.824
Operation	*36%*	*60.534*	2056					10.867	10.639	21.506	4.259	2.087	6.347	0.767	0.439	1.206	3.492	1.648	5.140	1.136	0.536	1.672
			2057					10.183	10.467	20.650	3.991	2.054	6.045	0.755	0.437	1.193	3.236	1.616	4.852	1.022	0.510	1.532
Cost function coefficients			2058					9.545	10.297	19.842	3.741	2.020	5.761	0.744	0.436	1.180	2.997	1.584	4.582	0.919	0.486	1.405
Oil fixed	*Koeffisient*	*2.00*	2059					8.949	10.130	19.079	3.507	1.988	5.495	0.733	0.434	1.167	2.774	1.553	4.328	0.826	0.462	1.288
Oil variable	*Koeffisient*	*2.00*	2060					8.393	9.966	18.359	3.289	1.955	5.245	0.723	0.433	1.156	2.567	1.522	4.089	0.742	0.440	1.182
Gas fixed	*Koeffisient*	*3.00*	2061					7.874	9.805	17.679	3.086	1.924	5.010	0.714	0.431	1.145	2.373	1.492	3.865	0.666	0.419	1.084
Gas variable	*Koeffisient*	1.00	2062					7.390	9.647	17.036	2.896	1.893	4.789	0.705	0.430	1.135	2.192	1.463	3.654	0.597	0.398	0.995
			2063					6.938	9.491	16.430	2.719	1.862	4.582	0.697	0.429	1.125	2.023	1.434	3.456	0.535	0.379	0.914
	Min olje	4.00	2064					6.517	9.339	15.856	2.554	1.832	4.387	0.689	0.427	1.116	1.865	1.405	3.270	0.479	0.361	0.840
	Min gass	4.00	2065					6.123	9.190	15.314	2.400	1.803	4.203	0.682	0.426	1.108	1.718	1.377	3.095	0.428	0.343	0.772
			2066					5.756	9.044	14.801	2.256	1.775	4.031	0.676	0.425	1.100	1.581	1.350	2.931	0.383	0.327	0.709
			2067					5.414	8.902	14.315	2.122	1.747	3.868	0.669	0.423	1.093	1.453	1.323	2.776	0.341	0.311	0.652
			2068					5.093	8.762	13.855	1.996	1.719	3.715	0.664	0.422	1.086	1.333	1.297	2.630	0.304	0.296	0.600
			2069					4.794	8.625	13.420	1.879	1.692	3.571	0.658	0.421	1.079	1.221	1.272	2.492	0.270	0.282	0.552
Unit cost of production (opex)			2070					4.515	8.492	13.006	1.770	1.666	3.436	0.653	0.420	1.073	1.116	1.246	2.363	0.240	0.268	0.508

Appendix X: Indirect Benefit-Expected additional Benefit from Petroleum Supply Sector.

Indirect Benefit-Expected additional Benefit from Petroleum Supply Sector

Conversion rate MSm3/bbl	**6289814**
Average revenue/bbl	**296.19**
Avg. EBITDA	29.32
Discount Rate	**3%**
Average no. of Emplyee/bbl	**#REF!**
Average Salary/year (NOK) (1000)	**630.27**
Average Service Sector EBITDA (2017)	**9.90%**
Avg Emplyee/year (Norway)	**0**

	NOK/bn	in 1000				
Year	*Revenue*	*Emplyees*	*EBITDA(%)*	*Prouction/MSm3*	*Prouction(bbl)*	*Revenue NOK/bbl*
2013	489.4	129.1	12.7%	215.390273	1354764755	361.2435283
2014	520.6	131.6	11.9%	218.435821	1373920685	378.915614
2015	457.4	112.7	10.1%	230.042229	1446922833	316.119139
2016	336.2	100.8	7.8%	232.959919	1465274560	229.4450536
2017	292.8	96.6	7.0%	238.430339	1499682484	195.2413281

Expected additional Supply Sector revenue from Lofoten

	in 1000 boe				
Year	*Lofoten extraction*	*bbl production*	*EBITDA/bbl*	*year(n)*	*DCF*
2024				4	
2025				5	
2026				6	
2027				7	
2028				8	
2029				9	
2030				10	
2031	24.831	24831185.97	728127357.36	11	526014695.03
2032	30.181	30181239.90	885007525.68	12	620726472.33
2033	33.991	33990732.56	996713661.25	13	678713503.22
2034	36.412	36412394.45	1067724295.63	14	705891543.55
2035	37.687	37686513.40	1105085413.50	15	709312275.55
2036	51.282	51281766.40	1503740381.12	16	937081290.68
2037	51.825	51825128.99	1519673456.95	17	919427433.77
2038	51.571	51570776.45	1512215051.86	18	888266967.02
2039	50.758	50757794.24	1488375892.88	19	848799974.35
2040	49.561	49561474.78	1453296097.58	20	804654812.89
2041	48.111	48110839.74	1410758980.64	21	758352468.53
2042	46.501	46500846.87	1363548998.12	22	711625996.70
2043	44.801	44801164.69	1313709047.11	23	665645534.01
2044	43.063	43062598.05	1262728883.09	24	621178937.44
2045	41.322	41321846.42	1211684648.52	25	578707336.32
2046	39.605	39605052.57	1161342930.15	26	538508593.46
2047	37.930	37930461.52	1112238728.56	27	500717703.00
2048	36.310	36310419.43	1064734071.95	28	465370511.16
2049	34.753	34752879.82	1019062181.61	29	432435329.73
2050	33.263	33262540.20	975360803.62	30	401835736.84
2051	31.842	31841700.83	933697388.09	31	373466952.71
2052	30.491	30490913.51	894088115.88	32	347207527.18
2053	29.209	29209471.74	856512270.46	33	322927606.61
2054	27.996	27995780.52	820923081.04	34	300494706.90
2055	26.848	26847634.70	787255885.87	35	279777671.66
2056	25.762	25762427.90	755434257.93	36	260649313.99
2057	24.737	24737308.53	725374579.92	37	242988107.17
2058	23.769	23769295.56	696989438.41	38	226679193.30
2059	22.855	22855363.58	670190119.25	39	211614906.65
2060	21.993	21992504.61	644888419.08	40	197694956.41
2061	21.178	21177772.14	620997937.32	41	184826374.55
2062	20.408	20408311.80	598434974.51	42	172923305.87
2063	19.681	19681381.80	577119133.26	43	161906696.04
2064	18.994	18994365.85	556973695.62	44	151703918.27
2065	18.345	18344780.31	537925833.46	45	142248367.09
2066	17.730	17730277.13	519906695.28	46	133479039.79
2067	17.149	17148643.80	502851402.52	47	125340119.56
2068	16.598	16597800.89	486698980.89	48	117780569.80
2069	16.076	16075798.28	471392245.83	49	110753745.89
2070	15.581	15580810.07	456877657.03	50	104217028.17
	Net Benefit from Petroleum Service Sector				**17,481,947,223**

Appendix XI: Indirect Cost-Expected Lofoten Fishing Income Loss:

Indirect Cost-Expected Lofoten Fishing Income Loss					
Revenue loss from 2024 to 2040 (16 years) (in 1000)					
(Regional 10 years Avg. Growth Rate 1.80%)					
		Revenue (NOK)			
Year	Revenue (NOK)		GR%	Year (t)	DCF
2007	1005346				
2008	1092138		8.63		
2009	984607		-9.85		
2010	928199		-5.73		
2011	1299305		39.98		
2012	1367648		5.26		
2013	991940		-27.47		
2014	1097524		10.64		
2015	1330361		21.21		
2016	1491233		12.09		
2017	1532201		2.75		
2018	1445937		-5.63		
			Average GR%	**4.72**	0.0472
			Discount rate	**3.00%**	
			EBITD (2016)	**15.00%**	
Year	Revenue (NOK)	EBITD (15%)		Year (t)	DCF
2019	1514185	227128			
2020	1585655	237848		0	
2021	1660498	249075		1	
2022	1738873	260831		2	
2023	1820948	273142		3	
2024	1906897	286035		4	254138
2025	1996902	299535		5	258382
2026	2091156	313673		6	262697
2027	2189859	328479		7	267083
2028	2293220	343983		8	271543
2029	2401460	360219		9	276078
2030	2514809	377221		10	280688
2031	2633508	395026		11	285375
2032	2757809	413671		12	290141
2033	2887978	433197		13	294986
2034	3024291	453644		14	299912
2035	3167037	475056		15	304920
2036	3316521	497478		16	310012
2037	3473061	520959		17	315189
2038	3636989	545548		18	320452
2039	3808655	571298		19	325803
2040	3988424	598264		20	331244
		Net Loss from fishing			**4948643**

Appendix XII: Indirect Cost-Expected Loss from Tourism in Lofoten:

Indirect Cost-Expected Loss from Tourism in Lofoten

Base callucation-2017	**Amount NOK**		
No. of tourist at Lofoten-2017	**350,000**		
Revenue from tourism pruchase	**170,000,000,000**		
Number of tourist (Norway)	**10,180,000**		
Average per tourist consumption	**16,699**		
Tourist Consumption Revenue in Lofoten-2017	**5844793713**		
Torurism Turnover-2017(Norway)	**84,948,700,000**		
Average per tourist Turnover	**8,345**		
Torurism Turnover-2017(Lofoten)	**2,920,633,104**		
Revenu to Turnover ratio	**49.97%**		
	Total tourist consumption		
		Change	Growth%
2011	128,526	8,356	6.10%
2012	136,882	8,274	5.70%
2013	145,156	6,260	4.13%
2014	151,416	7,253	4.57%
2015	158,669	11,126	6.55%
2016	169,795	0	0.00%
2017	169,795		
		Summation	27.06%
Average Growth rate	**4.51%**		
Discount rate	**3%**		

				in 1000
Year	**Tourism**	**Turnover**	**year (t)**	**DCF from tourism**
2017	5844793713	2920633104		
2018	6108419887	3052366638		
2019	6291672483	3143937637		
2020	6480422658	3238255766		
2021	6674835338	3335403439	1	
2022	6875080398	3435465542	2	
2023	7081332810	3538529509	3	
2024	7512585978	3754025956	4	3335403439.11
2025	7737963557	3866646734	5	3335403439.11
2026	7970102464	3982646136	6	3335403439.11
2027	8209205538	4102125520	7	3335403439.11
2028	8455481704	4225189286	8	3335403439.11
2029	8709146155	4351944965	9	3335403439.11
2030	8970420540	4482503314	10	3335403439.11
2031	9239533156	4616978413	11	3335403439.11
2032	9516719151	4755487765	12	3335403439.11
2033	9802220725	4898152398	13	3335403439.11
2034	10096287347	5045096970	14	3335403439.11
2035	10399175967	5196449879	15	3335403439.11
2036	10711151246	5352343376	16	3335403439.11
2037	11032485784	5512913677	17	3335403439.11
2038	11363460357	5678301087	18	3335403439.11
2039	11704364168	5848650120	19	3335403439.11
2040	12055495093	6024109624	20	3335403439.11
	Total NPV			**56,701,858,465**

Appendix XIII: Hypothetical Oil Spill Clean-up Cost (Inflation adjusted from online)

Oil Spill Clean-up Costs					
No. of Days	Oil leak/day (m3)	Total Oil Leak (m3)	Total Oil Leak (tonne)	Recovery costs/bbl (NOK)	Recovery costs (Bn/NOK)
45	3000	135000	47675.25	17608.23	0.839476767

1m3 cover to tonne	0.35315
USD/NOK	9
Recovery cost/tonne (2009)	1639
Recovery cost/tonne (2019) inflaion adjusted	1956.47

Appendix XIV: Externality Analysis-CO2 Emission and Carbon Tax Calculation:

Carbon Tax Calculation

		Year	Extraction (1,000 boe per year)	(Million boe)		Production Per Tonne	Carbon tax per year	Year	DCF Tax
			Oil	Gas	Total	Tonne	NOK (1000)		NOK (mil)
	NOK		813.44	457.56	1271	181571.43	101680		47694.68
Carbon Tax	560								
(per tonne)		2020				0.00	0	0	0.00
		2021				0.00	0	1	0.00
		2022				0.00	0	2	0.00
		2023				0.00	0	3	0.00
		2024				0.00	0	4	0.00
		2025				0.00	0	5	0.00
		2026				0.00	0	6	0.00
		2027				0.00	0	7	0.00
		2028				0.00	0	8	0.00
		2029				0.00	0	9	0.00
		2030				0.00	0	10	0.00
		2031	24.83118597		24.83119	3547.31	1986.49	11	1435.09
		2032	30.1812399		30.18124	4311.61	2414.50	12	1693.48
		2033	33.99073256		33.99073	4855.82	2719.26	13	1851.68
		2034	36.41239445		36.41239	5201.77	2912.99	14	1925.83
		2035	37.6865134		37.68651	5383.79	3014.92	15	1935.16
		2036	38.06022248	13.22154391	51.28177	7325.97	4102.54	16	2556.57
		2037	37.75413529	14.0709937	51.82513	7403.59	4146.01	17	2508.40
		2038	36.95208297	14.61869348	51.57078	7367.25	4125.66	18	2423.39
		2039	35.80125807	14.95653617	50.75779	7251.11	4060.62	19	2315.72
		2040	34.4164768	15.14499798	49.56147	7080.21	3964.92	20	2195.28
		2041	32.88559228	15.22524746	48.11084	6872.98	3848.87	21	2068.96
		2042	31.27475178	15.22609509	46.50085	6642.98	3720.07	22	1941.48
		2043	29.63299735	15.16816734	44.80116	6400.17	3584.09	23	1816.03
		2044	27.99608484	15.06651321	43.0626	6151.80	3445.01	24	1694.72
		2045	26.38955936	14.93228707	41.32185	5903.12	3305.75	25	1578.84
		2046	24.83118597	14.77386661	39.60505	5657.86	3168.40	26	1469.17
		2047	23.33284748	14.59761403	37.93046	5418.64	3034.44	27	1366.07
		2048	21.90201383	14.4084056	36.31042	5187.20	2904.83	28	1269.64
		2049	20.54287277	14.21000705	34.75288	4964.70	2780.23	29	1179.78
		2050	19.25719601	14.00534419	33.26254	4751.79	2661.00	30	1096.30
		2051	18.04499996	13.79670087	31.8417	4548.81	2547.34	31	1018.90
		2052	16.90504784	13.58586567	30.49091	4355.84	2439.27	32	947.26
		2053	15.83522973	13.37424201	29.20947	4172.78	2336.76	33	881.02
		2054	14.83284897	13.16293156	27.99578	3999.40	2239.66	34	819.82
		2055	13.89483661	12.95279809	26.84763	3835.38	2147.81	35	763.30
		2056	13.01791111	12.74451679	25.76243	3680.35	2060.99	36	711.11
		2057	12.19869589	12.53861264	24.73731	3533.90	1978.98	37	662.93
		2058	11.43380507	12.33549049	23.7693	3395.61	1901.54	38	618.43
		2059	10.71990481	12.13545877	22.85536	3265.05	1828.43	39	577.33
		2060	10.05375628	11.93874833	21.9925	3141.79	1759.40	40	539.36
		2061	9.432244665	11.74552748	21.17777	3025.40	1694.22	41	504.25
		2062	8.852397794	11.55591401	20.40831	2915.47	1632.66	42	471.77
		2063	8.311396892	11.36998491	19.68138	2811.63	1574.51	43	441.72
		2064	7.806581623	11.18778423	18.99437	2713.48	1519.55	44	413.88
		2065	7.335450902	11.0093294	18.34478	2620.68	1467.58	45	388.09
		2066	6.895660665	10.83461647	17.73028	2532.90	1418.42	46	364.16
		2067	6.485019518	10.66362428	17.14864	2449.81	1371.89	47	341.96
		2068	6.101482934	10.49631796	16.5978	2371.11	1327.82	48	321.33
		2069	5.743146509	10.33265177	16.0758	2296.54	1286.06	49	302.16
		2070	5.408238674	10.1725714	15.58081	2225.83	1246.46	50	284.33

Appendix XV: Scenario Based Cost-Benefit Table:

Costs	***Price Sensitivity Analysis***	
	Increase by 33%	***Decrease by 33%***
Direct Benefit	270	87
Indirect Benefit	17.48	17.48
Total Benefit	***287.48***	***104.48***
Indirect Costs	***62.49***	***62.49***
External Costs	**135.70**	**135.70**
Total Costs	***198.19***	***198.19***
Net Benefit/Loss	**89.29**	**-93.71**

Costs	***Reserve Sensitivity Analysis***	
	Reserve +16.5% /Price +33%	***Reserve -16.5%/Price -33%***
Direct Benefit	276	73
Indirect Benefit	20.37	14.60
Total Benefit	***296.37***	***87.60***
Indirect Costs	62.49	62.49
External Costs	135.70	135.70
Total Costs	***198.19***	***198.19***
Net Benefit/Loss	**98.18**	**-110.59**

Costs	***Costs Sensitivity Analysis***	
	Cost +.03%/Price +33%	***Cost -.03%/Price -33%***
Direct Benefit	178	86
Indirect Benefit	17.48	17.48
Total Benefit	***195.48***	***103.48***
Indirect Costs	62.49	62.49
External Costs	135.70	135.70
Total Costs	***198.1900018***	***198.19***
Net Benefit/Loss	**-2.71**	**-94.71**

Costs	***Combined Sensitivity Analysis***	
	Increase	***Decrease***
Direct Benefit	321	66
Indirect Benefit	20.37	14.60
Total Benefit	***341.37***	***80.60***
Indirect Costs	62.49	62.49
External Costs	135.70	135.70
Total Costs	***198.19***	***198.19***
Net Benefit/Loss	**143.18**	**-117.59**

Appendix XVI: Summary table of literature.

Table of Literature:

Author and Paper	Location	Research	Benefit and Cost (Direct/Indirect/External)	Methodology (Analysis techniques and Model)	Survey/Data Source	Result
Estimated costs and admissible claims linked to the Prestige oil spill (Loureiro, Ribas, Lopez, & Ojea, 2006)	Galicia and Northern Coast, Spain.	Analysis of societal costs incurred due to Prestige oil spill. Identified and Quantified all relevant costs.	Direct, Indirect and External cost. Included commercial, recovery, cleaning and environmental costs.	Analysis of affected sectors loss, salvage value, HEA, REA or RBA.	Secondary data: website, report and organizations, etc.	Estimated costs (m-million) Total cost- € 770.58m
Food for Thought Lofoten-Vesteralen: for cod and cod fisheries, but not for oil? (Misund & Olsen, 2013)	Lofoten and Vesteralen, Norway.	Outlining and reviewing different political and management arguments both for and against opening these areas.	Direct and employment benefit. Intrinsic environmental values.	Not specific. Mostly argument analysis.	Review of literatures and reports.	These two areas should be closed for petroleum activities due to environmental significance.
Pollution Embodied in Trade: The Norwegian Case (Peters & Hertwich, 2006)	Norway	Identifying pollution embodied in the trade to identify environmental impact accurately.	Environmental costs embodied in the trade based on CO_2 emission. (External)	IOA model (Input-output Analysis model)	Secondary data sources: Statistic Norway, Eurostat, CPI	Embodied CO_2 emission in important was 67% of domestic emission in Norway. DCs causing half of the pollution embodied in imports. Norway's Export industries are more pollution intensive than domestic.
An Empirical Analysis of IOPCF Oil Spill Cost Data (Konotovas, Psaraftis, & Ventikos, 2010)	Around the World	Identifying oil spill clean-up and total costs to contribute to environmental risk evaluation criteria for IMO (International Maritime Organization).	Cleanup costs (Direct), Socioeconomic losses (Indirect) and Environmental Costs (External).	Regression Analysis	Secondary data from International Oil Pollution Compensation Fund (IOPCF).	Marginal clean-up cost (MCC)= $23,085/tonne Marginal Total Cost (MTC)= $33,425/tonne Avg. Clean up costs= $1639/
A probabilistic model estimating oil spill clean-up costs--a case study for the Gulf of Finland.	Gulf of Finland, Finland.	Developing a probabilistic and systematic model for clean-up operation costs for Gulf of Finland.	Offshore and onshore oil spills clean-up costs (Direct cost).	Etkins model and Shahriari & Frost Model under Bayesian Belief	Literature survey and Expert opinion (group discussion).	Spill size 5000 tonne clean-up cost EUR12.1 Million. Spill size larger than 15000 tonne clean-up cost

(Montewka, Weckström, & Kujala, 2013)				Network (BBN) and designed a probabilistic model.		Major shoreline Oiling EUR 144 Million, Moderate Shoreline Oiling 46 Million, mean value 95 million.
Willingness to pay among households to prevent coastal resources from polluting by oil spills: A pilot survey (Liu, Wirtz, Kannen, & Kraft, 2009)	North Sea Coast, State of Schleswig-Holstein, Germany	Analysis of public perception toward valuing natural resources protected by oil pollution combat strategies and a monitory assessment for this.	Coastal natural resources (External costs).	Choice Experiment (CE) Method.	Pilot Survey (Questionnaire).	Willingness to pay WTP = EUR 29.1 per household year.
The economy of oil spills: Direct and indirect costs as a function of spill size (Liu & Wirtz, 2009)	North Sea area, Germany	Scenario analysis for estimating oil spill costs that includes biological and economic impacts and effort to combat.	Environmental damages (External cost), Socio-Economic costs and Response cost (Indirect costs).	Oil Spill Contingency Simulation System (OSCAR) and Economic Assessment Method.	Secondary data from OSCAR database and German North Sea Environmental Survey.	Total oil spill cost ranges from EUR 1.28 million to EUR 41.27 million. Oil recovery ration is from 37% to 77% based on spill size.
Assigning the performance and cost of oil spill remediation technologies. (Prendergast & Gschwend, 2014)	Around the world.	Describing financial benefit of oil spill recovery and where the responsible party doesn't have to pay for the recovered oil from environment.	Recovery costs.	Analysis of different models and findings from literatures.	Peer review scientific papers, government reports and published result of remediation technique performances.	Mechanical Recovery fine averter is from \$8,067 to \$31,533 per tonne and cost remediation is -30,00 to 30,000 based on spill size.
A probabilistic approach for a cost-benefit analysis of oil spill management under uncertainty: A Bayesian network model for the Gulf of Finland (Helle, Ahtiainen, Luoma, Hänninen, & Kuikka, 2015)	Gulf of Finland (GoF), Finland.	Developing a probabilistic model for a CBA of oil spill management and is application on Gulf of Finland oi spill valuation.	Expected yearly cost of tanker accident and damage of oil spill (Direct, indirect and external).	BN-based modeling (Bayesian Networks)	Existing statistics, expert knowledge, other models, papers, Finnish Environment Administration and regional rescue department.	Installing Automatic alarm system (AAS) is more cost effective than buying new oil combating vessel. Expected recovery costs is EUR 15 million (30km2 spill size)

Fossil fuels, employment, and support for climate policies (Tvinnereim & Ivarsflaten, 2016)	Norway	Variation of public attitudes based on their demographic and mostly employment background towards climate mitigation policies.	Employment opportunities (Indirect benefit-cost)	OLS and Logistic Regression analysis.	Nationally representative survey.	Petroleum sector employees are concern about climate problems compare to non-petroleum sector's but less likely to compromise with the policy if there is possible employment reduction.
Estimating a meta-damage regression model for large accidental oil spills (Alló & Loureiro, 2013)	Around the world.	Analysis of the key determining factors of the oil spill damage based on the legislation applied in preventing these accidents.	Oil spill damage (direct costs) and environmental damage (external costs).	Meta-Damage regression model. (OLS and TOBIT)	Database of ITOPF, Cedre and Damage Assessment, Remediation. CTX-4 and Restoration Program. Grey, OECD, NOAA and GL Group.	Average oil spill damage is $112.21 m to $528.31 m. Strict rules less damage, less accident since 2000 but more financial and environmental damage than before.
Assessing impacts of simulated oil spills on the Northeast Arctic cod fishery (Carroll, et al., 2018)	Northeast Arctic and Barents Sea, Norway	Analysis possible effect on fish stock in Lofoten-Vesterålen shelf due to different amount of oil spills with combination of different duration.	Indirect costs.	Simulation model	Historical secondary data.	Highest discharge with longest duration cause 43% reduction on fish population and lowest <3% to 12% maximum reduction on adult stock biomass.
Managing the Environmental Effects of the Norwegian Oil and Gas Industry: From Conflict to Consensus (GRAY, BAKKE, BECK, & NILSSEN, 1999)	Norwegian Continental Shelf (NCF), Norway.	In depth analysis biological effect of produced residual from offshore drilling and cutting.	Environmental Cost (External Costs).	Different statistical methods.	Secondary data from oil companies and other firms.	Affected area is within 3km radius, which is 10 times more than previously expected.
Post Petroleum Security in Lofoten: How identity matters (Kristoffersen & Dale, 2014)	Lofoten, Norway.	Post petroleum situation analysis on society and environment in Lofoten from an ontological viewpoint.	Social and Environmental Costs. (External Costs)	Giddensian approach.	Analysis of literature.	Decision on Lofoten petroleum extraction should be postponed until a certain period for both locality and nationally.

Elastic Oil: A Primer on the Economics of Exploration and Production (Mohn, 2010)	NCF, Norway	Effect of economics, technological development and policy on oil production.	Direct costs.	Econometrics	Secondary data	Technological development, economic and government policy has influence on oil reserve generation and production.
Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry (Bakke, Klungsøyr, & Sanni, 2013)	NCF, Norway	Biological effect of operation discharges of water and drill cutting from offshore oil and gas platforms.	Environmental and marine life (External cost)	"-omic" approaches and literature analysis.	Secondary data and literature.	Toxic contamination is with in <2km area. Fauna disturbance reduced to 500m from 5km. Physical stress on fauna and cause damage within .05 to 1km distance.
Escaping the Resource Curse and the Dutch Disease? When and Why Norway Caught Up with and Forged Ahead of Its Neighbors (Larsen, 2006)	Norway and Scandinavia	A comparative analysis of Norway's economic growth with Scandinavian countries and its recent slowdown (2002).	Direct and Indirect effect.	Regression analysis	Secondary data.	Conscious macroeconomic policy, well-regulated political and economic institutions, strong judicial system and social norm led Norway to avoid these problems. Political pressure due to vast overseas investment.
International Public Preferences and Provision of Public Goods: Assessment of Passive Use Values in Large Oil Spills. (Loureiro & Loomis, 2013)	Spain, UK and Austria.	Economic valuation of Environmental cost due to Prestige oil spill in the coast of Spain for three different EU countries Spain, UK and Austria.	Environmental Cost (External Costs)	Contingent Valuation Methodology (CVM).	Survey.	WTP per household: Spain = € 124.3 UK= € 80.87 Austria= € 89.08
A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf (Olsgard & Gray , 1995)	NCF, Norway	Intended to investigate contamination gradients, assess effects on benthic fauna and to evaluate measures such as diversity indices, indicator species and assessment of pollution.	Environmental Costs (External Costs)	Multivariate Statistical Analysis.	Survey	Initially the pollution caused sever reduction in organisms which are vital for benthic community and food for bottom living fish species.

Fish and oil in the Lofoten–Barents Sea system: synoptic review of the effect of oil spills on fish populations (Hjermann, et al., 2007)	Lofoten-Barents Sea, Norway.	Reviewing the effect of hypothetical oil spills in this area's fish stock, emphasizing the effect on eggs and larva stage for 3 main fish stocks.	Indirect costs	Simulation model.	Secondary data and EIA reports.	Ecosystem is stochastic in nature; therefore, it is impossible to determine the effect of oil spill even with the accurate knowledge of the system and other factors few years advance.
Measuring the welfare cost of climate change policies: A comparative assessment based on the computable general equilibrium model GEMINI-E3 (Bernarda & Vielleb , 2003)	Around the world. (7 zones)	Welfare analysis of current climate change policy and presenting and comparing various estimation.	External Cost	Computable General Equilibrium Model GEMINI-E3.	Secondary data.	Welfare costs are increasing from 2010 to 2040. Without trade of permit is lower.
Performance evaluation of an activated sludge system for removing petroleum hydrocarbons from oilfield produced water. (Telleza, Nirmalakhandanb, & Torresdeyc, 2002)	US	Petroleum hydrocarbon removal efficiencies analysis by a field activated sludge treatment system.	Environmental costs (external costs)	Standard Methods for the Examination of Water and Wastewater, Method 625, Method 602, Method 408.1.	Grab Sampling.	An activated sludge treatment system is capable of effectively removing TPH from oilfield generated produced water to concentrations of <1.0 mg/l.
Analysis of Environmental and Economic Damages from British Petroleum's Deepwater Horizon Oil Spill (Smith, Smith, & Ashcroft, 2011)	US	Environmental and economic loss from Deepwater Horizon.	Economic and environmental cost (Direct, Indirect and External costs)	Combination of accounting techniques.	Secondary data	$36.9 bn cumulative loss for BP, US gulf coast economy and environment.
An opportunity cost model of subjective effort and task performance (Kurzban , Duckworth , Kable , & Myers , 2013)		"Why does performing certain tasks cause the aversive experience of mental effort and concomitant deterioration in task performance?"		Opportunity Cost Model		

Fundamental Cost Analysis in Petroleum Upstream Industry – Part A (Rashed, 2013)	N/A	Importance of cost management in the upstream industry.	Direct costs.	Cost Accounting techniques.	Literature and secondary data	Cost reduction is important especially at exploration phase for avoiding financial constraint.
The Ocean Dimension of the 2030 Agenda: Conservation and Sustainable Use of the Ocean, Seas, and Marine Resources for Sustainable Development. (Visbeck , et al., 2017)	G20 countries	Proposing reformation of ocean governance process for sustainable and effective development.	Environment (Externality)	Externality (Ocean Development)	Literatures/reports .	Proposed effective ocean governance process, mobilizing resources and establishing global registry of Ocean commitment.
Resource revenue management and wealth neutrality in Norway (Mohn, 2016)	Norway	Analysis of Norwegian fiscal policy effectiveness based on Ricardian equivalence hypothesis.	Fiscal Policy (Direct/indirect effect)	Econometric Model. (Time series)	Secondary data	Norwegian revenue management model is not fully succeeded in separating the accumulation of oil and gas revenues from the expenditure of the same revenue.
Tragedy of Commons: Analysis of Oil Spillage, Gas Flaring and Sustainable Development of the Niger Delta of Nigeria. (BENEDICT , 2011)	Nigeria	Addresses on the environmental degradation and sustainable development of the Niger delta region.	Environmental Cost (Externality)	Analysis of literature.	Secondary data (Literature)	Need active EIA to ensure sustainable development and environmental pollution reduction through regulatory changes.
Beyond the Tragedy of the Commons: A Discussion of Governing the Commons: The Evolution of Institutions for Collective Action (Axelrod , 2010)	N/A					
The tug-of-war between resource depletion and technological change in the global oil industry	8 regions around the world.	Up to what extent the current technological changes has offset the effect of current resource depletion on the cost of finding additional reserve.	Direct costs. (tech cost vs production)	Linear regression analysis	Secondary data from EIA 2012 and others.	Since last decades resource depletion outweighed technological progress.

1981 - 2009 (Lindholt , 2013)						
Arctic oil and public finance: Norway's Lofoten region and beyond. (Mohn, 2019)	Lofoten Region, Norway	Valuation of Lofoten region oil and gas extraction public finance and valuation for Norwegian fiscal policy.	Direct revenue and costs	NPV and Econometrics	Secondary data	Expected additional fiscal capacity is 0.3-2.4%. permanent increase in govt. spending $24-$220 per capita annually.
Imperfect Environmental Policy and Polluting Emissions: The Green Paradox and Beyond (Werf & Maria, 2012)	Around the World.	Imperfect policy might result into "green paradox".	Externality	Hoel model and Hotelling model.	Literature and secondary data.	Weak Green Paradox and Weak Green Paradox occure due to imperfect policy implication.
Decision on oil and gas exploration in an Arctic area: Case study from the Norwegian Barents Sea (Hasle, Kjellén, & Haugerud, 2009)	The Barents Sea, Norway.	Analysis of handling environmental risks by the authorities and oil companies during petroleum extraction in the Arctic.	Environmental Cost (External costs)	Case study	Secondary data and authors experiences.	Environmental and reputational risks are not a vital concern at strategic level of oil companies rather than it is a technical issue and economic analysis that affect design and operational procedures.
Questioning Complacency: Climate Change Impacts, Vulnerability, and Adaptation in Norway (O'Brien, Eriksen, Sygna, & Naess, 2006)	Norway	Identify the wider social impact of climate change by analyzing the recent studies on climate change, adaptation and vulnerability in Norway.	Social and environmental cost (Eternality)	Downscale models	Literature study.	It is essential to focus on indirect effect in social context, more specifically in terms of vulnerability and adaptation.
Factors influencing future oil and gas prospects in the Arctic (Harsem, Eide, & Heen, 2011)	Arctic area (Russia, Canada, US, Norway and Greenland)	Whether or not Artic area will be a potential area for further oil and gas production.	Direct, indirect and external	Analysis of literatures.	Literature and reports study.	Arctic oil and gas production are dependent on complex set of variables, which alone or combinedly determine the further development.

Willingness to Pay for Preventing an Oil Spill in Vestfjorden: The Role of Use versus Non-Use Values. (Egeland & Frøystein , 2016)	Vestfjorden, Norway.	Potential environmental losses due to oil spill.	Environmental Costs (Externality)	Contingent Valuation Method	Internet administered survey	Total WTP is NOK 28.6 bn. Non-use value consists of 80% of total WTP within 10 years period.
Valuing the Recreational Benefits of Bore and Hellestø Beaches (Kleppe & Jensen , 2018)	Norway	Estimate the probable non-market value of Bore and Hellestø beaches based on different hypothetical situation that might affect the beach recreation.	Social and recreation costs (Indirect and external costs)	Individual travel cost model	Questionnaire survey, RP and SP data.	Sand dune scenario will cause an annual reduction of NOK 1855.71.
Of Seabirds and Tourists in Lofoten and Vesterålen (Bajada , 2016)	Lofoten & Vesterålen, Norway	Analysis of seabird tourism and cultural ecosystem service derive from tourist interaction with natural environment	Tourism (Indirect costs)	Grounded theory and both qualitative & quantitative.	Survey, interviews and field observation.	Mostly nature enjoyment and physical mental betterment motivate tourist. Other factors like gaining knowledge, satisfaction, view, culture, economic etc.
Risky businesses – A perspective on fishers' risk in the oil versus fish dilemma in Lofoten and Vesterålen (Høgi, 2010)	Lofoten and Vesterålen, Norway.	Analysis of associated physical risk of fishermen vs petroleum industry opening.	Fish (Indirect costs)	Qualitative and quantitative.	Interview and literatures.	Fishermen prefer physical risk during fishing over oil spill risk.
The effects of North Sea oil development on the development of tourism. (Butler & Fennell , 1994)	Shetland Isles, Scotland.	Impact of petroleum development in the North Sea area on tourism industry of Shetland Isles.	Tourism (Indirect costs)	Literature and data analysis.	Field research and Secondary data.	Shetland was not well protected from the possible negative impact arise due to oil related development and external event like oil spill. Vocational tourist reduced and professional visit increased.
Estimating the short-term economic damages from the Prestige oil spill in the Galician fisheries and tourism. (Gil, Blanco, & Rodriguez, 2006)	Galicia, Spain	Estimating the short-term economic damages on fishing and tourism of Galicia due to Prestige oil spill incident.	Fishing and tourism costs (Indirect costs).	Economic model and data analysis.	Secondary data	Cleaning and restoration €559.0 Coastal fisheries and aquaculture €64.9 Tourism €133.8 Total €761.7

Complacency or resilience? Perceptions of environmental and social change in Lofoten and Vesterålen in northern Norway. (Kaltenborn, Linnell, Thomassen, & Lindhjem, 2017)	Lofoten-Vesterålen, Norway	Analysis of perception on petroleum extraction activities of the inhabitants.	Social and environmental benefit and cost (Indirect and external benefit/cost)	ONEWAY ANOVA	Questionnaire Survey/interview survey	Perception of petroleum extraction in LV region varies based on age, sex and other demographic factors.
Differing Discourses of Development in the Arctic: The Case of Nature-Based Tourism in Northern Norway. (Amundsen, 2012)	Northern Norway	Analysis of various discourses on regional and local tourism development in Northern Norway.	Tourism (Indirect effect)	Thematic model.	Interview and literatures.	Disconnection between national strategies for tourism and it focus on tourism development and local perceptions. Also, spatial difference is a concern.
Inadequate risk assessments – A study on worst-case scenarios related to petroleum exploitation in the Lofoten area. (Hauge, et al., 2014)	Lofoten area, Norway.	To analyze the key uncertainty associated with defining the risk assessment of a worst-case scenario for Lofoten area and explain how they affect the relevance of such assessment.	Oil spill clean-up costs (Indirect cost)	Simulation model	Secondary data and field research.	Alternative way of decision making is essential. Lack of proper risk assessment.
A high-level synthesis of oil spill response equipment and countermeasures. (Ventikos, Vergetis, Psaraftis, & Triantafyllou, 2004)	Around the world.	Analysis of oil spill clean-up techniques and method and propose an efficient technique for better oil spill response operations.	Clean-up costs (Indirect)	Compatibility analysis.	Secondary data	4 steps oil spill response technique/method need to be used in structural and uniform framework.
Governing resources, governing mentalities. Petroleum and the Norwegian integrated ecosystem-based management plan for the Barents and Lofoten seas in 2011 (Dale, 2016)	The Barents Sea and Lofoten, Norway.	Analysis of how knowledge-based production is used as a basis for the political process of producing a revised management plan, however, this is politicized by knowledge inclusion and exclusion of knowledge.	Social effect (external)	Ontological and literature analysis.	Secondary data, fieldwork trip.	Suggested 4 findings to improve IMP-BL 2011 for better governance.

Understanding the Effects of a Tourism Crisis: The Impact of the BP Oil Spill on Regional Lodging Demand. (Ritchie, Crotts, Zehrer, & Volsky, 2013)	US	Analyzing the impact of BP Gulf oil spill in the tourism industry and sub industries in different region of US.	Tourism industry (Indirect costs).	System perspective	Secondary data sources	Complex combination of changes has experienced by the tourism industry in these regions.
Modified Assessment Methodology for Mechanical Recovery Capacity for Oil Spill Response at Sea. (Zhang, Han, & Shi, 2015)	China	Critical analysis of mechanical oil recovery formula and suggest improvement.	Oil Clean-up (Indirect costs)	Case Study	Experiments	2 new parameters suggested. Thickness of oil at sea with time changes. Amount of oil and water mixture to be collected.
Spill Response Evaluation Using an Oil Spill Model (Hospital, Stronach, McCarthy, & Johncox, 2014)	Canada	To evaluate to point the way to the development of a risk-informed enhanced oil spill response capacity that would be capable of managing large spills	Oil Clean-up (Indirect costs)	Mitigation modeling.	Primary data	Proposed to reduce the time for the initial response due to the effect on the current of floating oil and close shoreline proximity.
The Oil Price Collapse and the Birth of a Tourist Nation. (Xie & Tveterås , 2018)	Norway	Analysis of the effects of oil price downfall on tourism industry.	Tourism (Indirect effect)	Regression analysis	Secondary data form SSB, the World Bank etc.	Rich countries with wealth inflation prices of tourism services can have negative consequences in developing its tourism industry.