Abstract

This thesis examines whether it is possible to measure the effects of government influence on the intensity in booked resources (development intensity) in offshore petroleum provinces. The energy policy and resource management literature generally attributes the rate of booked resources to technical and economical factors. This dissertation challenges those beliefs, arguing that *government policy* may have a significant impact on the said rate. By looking at the creaming phenomenon in past exploration trends, as a new way of measuring the effects of government influence, I attempt to bring original insights and nuances to the research field. Employing John S. Mill's "Method of Difference" and the critical case study, I analyze how government influence has affected the rate of booked resources in the three Norwegian petroleum provinces. I have gathered data from the Norwegian Petroleum Directorate, previous research, and published reports. I have employed bargaining theory to deduce expectations for actor preference and behavior, while petroleum exploration theory has inspired my assumptions for the optimal development intensity. The dissertation finds that the Norwegian government, through its policy choices, has moderately affected the development intensities in the three relevant petroleum provinces. Since this political impact *can* be observed in the creaming curves, ceteris paribus, I conclude that such curves may indeed serve to measure the effects of government influence for the intensity in booked resources.

Foreword

They say that writing a master's thesis is a lonesome and demanding process, riddled with challenges and obstacles. To some extent I have found this to be true, at least in regards to the writing process. I therefore wish to thank my family and friends for their support and belief in me during this period. I have also had great pleasure working with my talented classmates, discussing each other's trials and tribulations, as well as having many interesting and amusing lunchtime conversations.

I wish to direct special attention and thanks to my advisor Jonathon Moses, who has inspired me through my years as a bachelor and master's student with interesting lectures in many different courses. He has shown faith in both me, and my project, and he has given me important advice on how to overcome my challenges. It has truly been a privilege to study under such an amazing lecturer.

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List of acronyms

HG: Host government.
NPD: The Norwegian Petroleum Directorate.
NCS: Norwegian continental shelf.
IOC: International Oil Company.
NOC: National Oil Company.
MNC: Multinational Company.

1.0 Introduction

In a world powered by fossil fuels, those nations lucky enough to be endowed with such finite resources might find themselves with a difficult conundrum; at what pace should this resource be developed? If a state chooses to develop the resource with a high level of intensity (i.e. discovering and developing the resources quickly), its economic situation can change fast and drastically, but it may also fall prey to economic illnesses as Dutch disease or the resource curse[1]. However, if a host government (HG) chooses to develop its petroleum resources slowly, it will have more control over the adverse effects of the new and large increase in state revenue, but at the same time it will be more difficult to attract foreign investors (i.e. International Oil Companies, IOCs) to help extract the resource.

The petroleum resource management and energy policy literature is mostly concerned with technical, financial, and economic perspectives on how growth in booked petroleum resources is affected (e.g. Brandt 2006; Nashawi et al. 2010; Chavez-Rodriguez et al 2015; Smith 2014; Mohn & Osmundsen 2008; Kaufmann 1995). However, few works in this field consider the political science perspective that I am proposing for this thesis. The management of petroleum resources can sometimes be seen as a tug of war between IOCs and HGs (Al-Kasim 2006:46), where the level of development intensity is a product of this bargaining relationship. However, there seems that an indicator of government influence has yet to be developed. Therefore, in this thesis, I will examine if trends in exploration activity in a petroleum province[2] can be used to indicate the degree of government influence. As the actors involved have different preferences and time horizons for costs and profits (and implicitly the development intensity) (Al-Kasim 2006:132), the bargaining relationship between the actors is never static, and economists often have a hard time capturing the dynamics of that relationship (Stopford, Strange & Henley 1991:137). Therefore, an easily interpretable indicator to the degree of government influence can be a way of capturing this. On this note, the research question I pose for this thesis is:

[1] Dutch disease leads to deindustrialization due to exchange rate appreciation, making manufactured goods less competitive, which again leads to a decline in exports and an increase in imports (A Dictionary on Business and Management Online 2009). When a state, well endowed with natural resources, show poor economic performance and unbalanced growth compared with resource-deficient countries, it is said to have fallen prey to the resource curse (Auty 2001:3; Luong & Weinthal 2010:1).

[2] A petroleum province is in this thesis regarded as a geographical area with similar conditions, in which drilling operations are conducted.

Is it possible to use past exploration trends as an indicator to the degree of government influence on development intensity in a country's petroleum sector?

Proposing a new way of indicating government influence through past exploration trends, I hope to further the understanding of how a HG can exert influence over how fast the natural resource base is explored and developed. This indicator is called the *creaming phenomenon*, presented through creaming curves. A creaming curve is an easily interpretable indicator with which we can measure the degree of government influence over development intensity, as it shows the sequence and size of the discoveries made within the province. The existing resource management and energy policy literature often attribute deviations from the development intensity expected by their economic models to technical, fiscal, or economic variables (e.g. Brandt 2007; Mohn & Osmundsen 2008; Nashawi et al. 2010; Smith 2014; Lund 1992; Blake 2013), and that other explanations sometimes are regarded as "institutional shocks" (e.g. Chavez-Rodriguez et al. 2015). However, these 'shocks' can in many cases be caused by prudent resource management strategies, controlling the rate in booked resources. If one can easily measure the degree of government influence on this booking rate, one can better explain past growth and estimations of future growth in a petroleum state's resource base.

The reason why it is important to research the effects of government influence is because natural resource management is very important to a HG with newfound resources, as mismanagement can overheat or starve its economy, and arrest its manufacturing industry. Resource management encompasses many different strategies, but understanding how a HG can affect the development intensity may bring new insights and empirical evidence as to why some states have succeeded and others have failed in the resource management game. If it is possible to develop a simple measurement for government influence on petroleum activities by analyzing the development intensity and use this comparatively across states and time, it can have significant political and commercial possibilities with regards to resource management policy and foreign direct investment (FDI).

In this thesis, I will analyze how development intensity has been affected by government influence in the Norwegian petroleum sector. When Norway discovered petroleum resources in the late 1960s, there was great optimism about the state's economic future. However, the discoveries came in the wake of the crisis in the Netherlands in that same decade, which spurred great fears for the revenue's effect on the domestic economy. For this reason it became highly important for the Norwegian authorities to assert control over how their new resource base was to be exploited. The Norwegian Model of petroleum governance is internationally celebrated (Velculescu 2008), and Norwegians themselves often refer to the petroleum era as it was a fairy tale. In light of the large number of petroleum nations that have mismanaged their natural resource endowments, and suffered under economic illnesses like the Dutch Disease and the resource curse, it is remarkable that Norway has so far avoided that fate. Of course, there are also many other tools a HG uses to fight these illnesses, but in this thesis I will focus on how a HG influences the rate of booked resources. Thus, I will present a political science perspective on the effects of government influence on the development intensity in the three petroleum provinces on the Norwegian Continental Shelf (NCS). More specifically, I will look at how Norwegian authorities have controlled the development intensity through restrictive licensing and regulatory policies for slowing the development intensity.

Based on bargaining theory and petroleum exploration theory, I will deduce and generate assumptions as to how the succession of discoveries in a petroleum province should follow an optimal path of development intensity ('optimal development intensity'). The optimal path is seen through the discovery of fields in a diminishing order, from the largest to the smallest. I will further postulate assumptions as to how the 'observed development intensity' (presented through creaming curves) can be affected by technical, economical, geological, and political variables. If we observe any deviation between the 'optimal development intensity' and the 'observed development intensity' (i.e. the creaming curves), and given the above-mentioned assumptions, I hypothesize that the deviation can be explained by the existence of government influence after other alternative explanations have been adequately controlled for.

To test my hypothesis, I will look at three petroleum provinces within the Norwegian case. I start off by presenting the theoretical framework for the thesis, discussing a range of different assumptions and expectations for how the dependent variable is affected. Subsequently, I present the methodological framework, showing how the main variables are measured against each other and how to control for other theoretically relevant variables. This section also highlights my treatment of all relevant data, emphasizing the construction of different figures and graphs. Next, the empirical analysis examines the curves for each province, discussing the location and water depths of each significant discovery. The discussion following the empirical analysis argues that the deviation seen between the 'observed' and 'optimal' development intensities, ceteris paribus, reveal how government policies influenced the development intensity in all three provinces. Finally, I conclude that the Norwegian government has indeed affected the development intensity to a moderate degree, through a clever regulatory regime and licensing policy.

2.0 Theory

This chapter will discuss some of the theoretical arguments concerning what is expected to affect development intensity in the petroleum sector. Firstly, I describe the dependent variable (Y) *development intensity* and the main independent variable (X_1) *government influence*. I also briefly discuss other variables thought to have an effect on the dependent variable. The bargaining between the actors relevant to the management of petroleum resources, chiefly the government (and relevant state institutions) and the IOCs, affect the main independent variable. Therefore, secondly, I examine the relevant expectations for the actors' preferred outcomes of the bargaining processes. In the third section I will look at the behavior of the relevant actors involved in the petroleum sector and the bargaining power between them. The second and third sections will be used to generate expectations of a government's ability to affect the development intensity. The fourth section is a presentation of the creaming phenomenon and the creaming curve, the graph that will be the main object of investigation in this thesis. The fifth section discusses exploration theory and reserve generation. In the sixth section, I discuss the 'optimal' and 'observed' development intensities. Here, I argue why it is important to control for other theoretically relevant variables that are thought to have an effect. Finally, in the seventh section of this chapter I propose a hypothesis based on the theoretical framework presented above, which postulates that a government's ability to affect the development intensity in a petroleum province *can*, ceteris paribus, be measured by analyzing creaming curves. To avoid measurement error, the base line for the theoretically optimal trajectory of the creaming curve is presented in section 2.4. It is also necessary to control for other theoretically relevant variables to exclude alternative explanations, which is further discussed both in sections 2.1.3 and 3.2.

2.1 Variables

The following section will present the different variables that are relevant for this thesis. Firstly, I will present the dependent variable and explain how it will be measured. Secondly, I will discuss the main independent variable and how it is thought to affect the dependent variable. Finally, I lay out the other variables that are thought to affect the dependent variable. I emphasize that such variables must be controlled for in order to properly measure the said independent variable's impact on the dependent variable

2.1.1 Development Intensity (Y)

In this thesis the dependent variable is *development intensity*. This variable combines the theoretical assumptions behind the creaming phenomenon (section 2.4) and conditional probabilities in exploration theory (section 2.5). The development intensity is thought to vary between an optimal and observed path (discussed in section 2.6), and the degree of variation will further be measured qualitatively by examining the shape of the creaming curve in each province, measuring them on a scale from Z1-Z5, as explained in the same section. The creaming curve shows the amount of petroleum discovered over time, where each increase in the curve signifies a discovery. The further the distance between the largest discoveries in the creaming curve, or if these are observed close together at the end of the curve, the more it deviates from the optimal path.

The development intensity is thus set to vary between high and low extremities, where the placement of the largest discoveries is the main object of investigation. The highest possible development intensity is characterized by the succession of discoveries by diminishing order, or in other words that the largest petroleum deposit is discovered first and that the size of subsequent discoveries should be smaller than its former. This is called the creaming phenomenon (Meisner & Demirmen 1981:3). Moderate or low development intensity is measured qualitatively by the distance (by the number of small and medium sized discoveries) between the largest discoveries, while the most sub-optimal development intensities are those where the largest discoveries appear at the end of the curve. The lowest possible development intensity is no development intensity (i.e. no discoveries made). If we observe a deviation between the 'observed' and 'optimal development intensity', there must be some variable restricting exploration activity. I further elaborate on this below.

The highest level of development intensity will be called 'optimal development intensity', while the creaming curves we examine will be called the 'observed development intensity', and is further explained in section 2.6. It is important to note that the observed development intensity never would follow a smooth linear curve as it does in Figures 3 and 6. The term 'development intensity' could indicate that the thesis will focus on the pace a *field* is developed, and may thus be a bit confusing. As development intensity depends on exploration activity and the drilling of exploration/wildcat wells (through which discoveries are produced), I emphasize that the meaning of the term signifies the pace at which a petroleum province is explored, and how quickly the largest discoveries are found.

Development intensity can also be described as the tempo in petroleum activities, as it has been by the Norwegian authorities (Al-Kasim 2006:73; Tempo-utvalget 1983:7). The reason for choosing the wording *development intensity* over *tempo* is because the former more accurately describes the advancement of exploration and the growth in booked resources, while the latter mainly encompasses production volumes and investment levels in the petroleum sector (Tempo-utvalget 1983:7). Large discoveries will naturally push production volumes and investment levels up, because large fields require larger investments in infrastructure, and production volumes will increase as more production wells are drilled. A government's interference with production will both damage the economy of the field and the relationship and trust with the licensees (Al-Kasim 2006:199). Production volumes and investment levels might also be misleading, as they are heavily biased on subjective perceptions of future production figures (Al-Kasim 2006:39). Therefore, examining creaming curves provides a better picture of how the growth in booked resources has been affected over time.

It may also be important to point out that *development intensity* can have different meanings in the literature, as for instance *intensity of development* in Smith (2014) refers to single field development. However, in this thesis *development intensity* will be measured as stated above. We also differentiate between exploration activity and development activity. Exploration technology is to a large extent independent from development technology, as it is based on highly mobile assets and also much cheaper as it does not involve placing fixed infrastructure on the seabed.

2.1.2 Government influence (X_1)

To define *influence* is a highly controversial matter, even for political scientists. The main problem with this definition is its interchangeability with the term *power*, a term that can be associated with more coercive means of influence. However, this is not a debate that will be discussed in this thesis. This thesis borrows the definition of influence from Michael Sodaro, who defines influence as "the capacity to affect outcomes indirectly or partially" (Sodaro 2008:101). By modifying Sorado's definition of *political influence,* this thesis argues that *government influence* is the government's[3] capacity to affect other actors' decisions, actions, or behavior without fully controlling them, in order to achieve a desired outcome (ibid.). The term *actors* incorporate other governments, oil companies (both IOCs and national oil

[3] The word 'government' is used throughout this thesis as a term for the state apparatus, unless otherwise specified by stating the specific state institution.

companies, NOCs), Non-Governmental Organizations (NGOs), and other national and supranational organizations. Of these, IOCs will be the actors of importance in this thesis. Stopford et al. (1991) also employ the term *government influence* in the same manner as in this thesis, as a variable describing the bargaining power of a state.

There are two main ways in which governments can influence development intensity: regulations and obligations. In the regulations component we find regulatory measures such as the fiscal regime, concessionary and contractual licensing systems, and health, safety and environmental (HSE) regulations. The obligations component consists of different obligations that IOCs take on as they sign contracts to explore or develop a petroleum province. Among other things, these obligations can be related to postponement of development, research and development (R&D), landing petroleum at designated areas, and sharing information. Government influence will be measured by examining the 'observed development intensity', i.e. the creaming curves, and how much it deviates from the 'optimal development intensity', based on the scale presented in section 2.6.

2.1.3 Other variables

Abstracting from the main independent variable selected for this thesis as well as other exogenous variables such as war or natural disasters, there are three other variables thought to affect the dependent variable. These variables will be shortly discussed here, and how to control for these variables will be discussed in section 3.2 in the methodology chapter.

The first variable that can affect development intensity is technology, the effect of which is lagged. Quite simply, technology can affect the development intensity by making previously inaccessible prospects (due to technological challenges) suddenly accessible. IN the absence of new technology, an explorer can be inhibited from discovering and developing the resource base in its preferred order, causing it to develop resources with a higher cost/reward ratio earlier than it normally would. This can cause the creaming curve to exhibit larger discoveries at later stages in the exploration phase. The two main issues where a technology lag can limit the development intensity are: 1) the availability of the resource, such as water depths in offshore drilling; and 2) the environmental conditions of the petroleum province. If the environment is harsh, it is expected that challenges related to developing technology capable of handling such harsh conditions must be developed. As the technologies for exploration activity are different from development technologies, I argue that exploration technology is the most important for the purposes of this thesis. This is because a petroleum discovery is not dependent on being developed (e.g. not deemed commercially viable), and a prospect is evaluated on its own merits. If left uncontrolled, deviations from the 'optimal development intensity' might be misinterpreted as government influence. This thesis will control for technological lags by comparing across petroleum provinces, as it is assumed that the conditions within one province are largely the same, but that the conditions differ across provinces. This will be further discussed in the following chapter.

The second variable that is thought to affect the development intensity in a petroleum province is the fluctuations in oil prices, which can influence exploration cycles. Exploration activity is costly, and in times of low oil prices it can be expected that there will be less exploration than in times of high oil prices. It is however expected that price fluctuations have less effect on exploration cycles in regulated high-tax environments than in unregulated petroleum provinces (Mohn & Osmundsen 2008:316). However, such fluctuations are automatically controlled for when analyzing the most significant discoveries in a creaming curve. This is because the prospect with the largest probability of reward will be drilled first, which will be further discussed in sections 2.5 and 2.6. Also, the price of the initial well should chiefly be the same wherever it is drilled within a petroleum province, as the geological and technological conditions should remain roughly the same. As exploration activity is less dependent on infrastructure, it is also less costly. A petroleum explorer will drill a prospect, not knowing exactly which sort of petroleum[4] it will contain. This can result in discoveries that will not be developed, e.g. due to long distance to gas markets, or that the size of the deposit does not justify development from a break-even price point of view. However, this is only thought to affect smaller discoveries. A petroleum prospect will only be drilled if it is expected to generate a profit, which means that the development intensity is cost dependent. Thus, in times of high oil prices, it is expected that more prospects will be commercially viable to drill and develop, thus extending the exploration phase, especially in the late stages. If a prospect is found to contain a type of hydrocarbon that is not expected to generate a profit the discovery will be abandoned, until an oil price increase eventually makes it profitable.

Assuming that petroleum exists in the province, the price of oil does not have much impact on the early phases of the exploration phase, given that the curve follows an optimal path. This is

[4] Petroleum is defined as "naturally […] generated hydrocarbons and associated non-hydrocarbon substances […] natural hydrocarbon may occur in a semi-solid, liquid, or gaseous phase, respectively referred to as asphaltic bitumen (including tar and natural asphalt), extra-heavy oil, heavy oil, light oil (the latter also referred to as conventional oil), or natural gas" (Taverne 2008:1).

because the rewards from the largest discoveries almost always exceed the costs. It is also important to point out that some fiscal regimes allow the IOCs' costs to be carried forward, meaning that the costs of exploration can be deducted from revenue generated by earlier discoveries. This can also have an effect on the duration of the exploration phase, but is not thought to have particular effect on the early phases.

The last variable that is thought to affect the development intensity is geology. As petroleum deposits are located in different sedimentary layers (e.g. Paleocene, Eocene, etc.) that have been created over millions of years, the result lies in different drilling depths, reservoir characteristics etc. Also, the characteristics of the source rock, such as permeability and its type (limestone, sandstone, etc.) can have an effect on the IOCs ability to develop it. If a deposit of a certain size is thought to be harder to put into production due to geological variables, it is assumed that the explorer may drill a less promising but geologically more available prospect instead.

How these variables will be controlled for is discussed in section 3.2 in the following chapter. The following section discusses the actors' development intensity preferences, and how their bargaining power is affected is discussed subsequently thereafter.

2.2 Assumptions of actor preferences

This thesis argues that the pace of development intensity in a petroleum province is a product of the bargaining relationship between the HG and the IOCs[5], and that government influence is determined by the HG's bargaining power. This bargaining power is projected on the IOCs as a group, on which the HG places restrictions and obligations to secure its political goals. Before discussing this bargaining relationship, it is important to discuss the actors' preferred development intensity outcome. This will provide a better understanding of how the development intensity is a product of this relationship.

For an IOC, the most important aspects of operating in the petroleum industry are costs and profits. Thus, it is reasonable to assume that IOCs would favor an outcome with as few restrictions on exploration activity as possible, to have the opportunity to generate as large returns as possible. IOCs usually have a shorter time horizon than the HG, focusing mainly on costs and rewards in the near future (Al-Kasim 2006:132). A result of this is that IOCs always want the highest possible development intensity. The only reason that can push it towards a

[5] In this thesis "IOCs" encompass all exploration firms, also national oil companies (NOCs).

more moderate level is assumedly firm reputation. If a firm explores and develops areas in which they don't have the technology to do so responsibly, they can be branded as a polluter and thus become unwanted by other HGs, or that consumers will buy from other IOCs. However, environmental concerns are thought to be much less important for IOCs than for HGs[6].

The preferred development intensity for a HG can vary to a large extent, based on its political goals. For instance, it can be important to protect the domestic economy by regulating the level of revenue generated. Also, sustaining a certain level of activity can be important to protect the work force from fluctuations in available jobs and control the employment figures. However, it can also be expected in some countries that the political elite can prefer a much higher level of development intensity, enabling them to embezzle as much of the revenue as possible while still in power. Therefore it is important to chart the political goals (and perhaps also the government's legitimacy) of the HG as a determinant for its preferred development intensity.

The economic priorities of a HG usually stretch over a longer time horizon than that of the IOCs because it is usually not limited to a cost/profit perspective, but has long-term economic and social priorities as well. Also, as the owner of the natural resource, a HG would want to capture as much of the revenue generated as possible through its fiscal regime. However, the size of the revenue claimed by the government must not be too high, as it can create disincentives for investments as well as suboptimal resource extraction. It is the HG's task to find a suitable balance between how much of the revenue is allocated to the IOCs and how much it should claim for itself, letting it secure as much of the revenue as possible while still promoting an attractive investment environment fostering optimal resource depletion and exploration incentives. The decisions that are made and the policies implemented are dependent to some degree on the quality of the institutions set to manage the resource, and they would have to be made on strategic grounds, considering the availability of the resource, the quality of the oil, the resource potential, etc.

A HG can also have environmental priorities that can affect the development intensity. For instance, it can withhold promising acreage in fragile areas until environmentally friendly technology is developed. The perception of environmentally safe technology is assumedly subjective. Therefore, the HG can regard the technology as insufficient, but the IOC vice

[6] One great example of this is the Niger Delta, which is heavily polluted by IOCs (Okonta & Douglas 2003).

versa. As with all other preferences, the priority of protecting fragile areas could change for political reasons, like a change of government or regime. Also, the HG can have social priorities, like maintaining stability in employment in both the petroleum sector and competing sectors. If a HG can achieve these priorities through affecting the development intensity, it will implement policies to do so. However, these policies will be within the limits of its bargaining power.

In a negotiation context, these priorities manifest themselves as win-sets. Each actor has a win-set that varies from essentially getting everything they want from the negotiations, to not being able to reach an agreement. This thesis assumes that the IOCs share a common win-set, since they all more or less share similar interests vis-à-vis the HG, albeit independent from each other. They are also set to operate within the same framework presented by the HG, meaning that all of them are negotiating with the same actor. This should roughly give them the same preferences and win-sets regarding the level of development intensity. The reason behind this assumption is that it is against the HG's interest to give one IOC a monopoly; it prefers to create competition amongst them in order to improve the HG's bargaining power. Because of this competition, the IOCs will have to share a certain minimum regarding the level of development intensity at a point where it becomes too low for most of them to accept. It is probable that there will be IOCs willing to accept an even lower level of development intensity, because these don't necessarily have the bargaining power needed to bring the development intensity up. It is however not likely that these will be rewarded a license, because their lack in bargaining power (technology, capital, etc.) makes them unattractive for the HG, since they don't possess the needed assets to develop the resource. A successful agreement will come when the HG's win-set overlap with that of the IOCs (Putnam 1988:435-437).

The following two-dimensional model (Figure 1) can illustrate the hypothetical relationship between the actors' preferences. On the left side is the lowest possible development intensity (very restricted exploration); on the right side is the highest possible development intensity (unrestricted exploration). The red brackets ({ }) illustrate the HG's preferred development intensity, and the blue brackets ([ ]) illustrate the IOCs preferred development intensity[7]. The development intensity will be set somewhere in between where these win-sets overlap ("X").

[7] I emphasize, the span of each win-set is also hypothetical. The span of each win-set will be decided on the goals of each actor, and can thus vary from case to case, and possibly over time.

[{————————————————[—X—}————————————————]]

Low DI　　　　　　　　Moderate DI　　　　　　　　High DI

Figure 1 Hypothetical win-set model

The black brackets in each end of the model illustrate the range from no development intensity to 'optimal development intensity'.

2.3 Actor Behavior and Bargaining

The development intensity is highly dependent on both a HG's aim and ability to affect it. To understand how a HG can assert influence on the IOCs, and on the dependent variable, we need to look at how they interact with each other and which factors strengthen or weaken their bargaining power. The relative distribution of bargaining power between the IOC and the HG is largely regarded by the literature as the most important part of the relationship between them. The relationship, and implicitly the distribution of bargaining power, will in practice be tested already in the pre-investment phase, when negotiating a wide range of issues, from ownership shares to taxation, as well as the size of the proposed investment (Jakobsen 2012:70).

To illustrate how this relationship is thought to affect the development intensity, a causal mechanism can be traced schematically, as done below in Figure 2: the HG affects the development intensity in the petroleum provinces indirectly, by imposing regulations and obligations on the IOCs operating within it. The argument is that since a HG is not directly capable of controlling the behavior of IOCs or drill for petroleum itself, they must control the environment the IOCs operate within. The better bargaining position a HG has the more restrictive policy choices it can take to indirectly affect the development intensity. If the HG wants high development intensity, the regulations and obligations imposed on the IOCs will be less.

Figure 2 Causal mechanism

As petroleum activity is thought to cease if the HG is unable to make a deal with the IOCs, a low level of development intensity could indicate a strong government bargaining position.

The bargaining relationship between the actors is never static, and economic analysts have a hard time capturing the dynamics of this relationship. Governments choose their policies on political grounds. Assuming the government is legitimate, the politicians are responsible for making the right choices based on the public interest and their responsibility towards the electorate. Also, to understand government policy, it must be seen as a whole, understanding that there is intra-governmental bargaining between ministers, between political parties, and bargaining with labor unions and business associations (Stopford et al. 1991:136). This legitimizes the need for a political science perspective on how the development intensity in the petroleum industry can be affected by government influence.

The relationship between the HG and IOCs is highly affected by the distribution of bargaining power, and this distribution has been affected by many different factors through the years. According to Stopford et al. (1991), manufacturing states (especially developing ones) have over the past decades lost bargaining power as a *group* towards multinational companies (MNCs) due to the increased competition to attract FDI (p.215). This creates a so-called race to the bottom, where each state in competition with each other, reduces its demands to secure the investment. This is however not assumed to affect the petroleum industry to the same degree, because of the finite nature of the resource.

The major IOCs also lost much of their power in the mid-seventies as OPEC came into existence, as well as by the many resolutions of the UN General Assembly on Permanent Sovereignty over Natural Resources, and the rise of the NOCs (Jakobsen 2012:74). As an example, although outside the scope of this thesis, Russell & Dawe (2013) argue that the bargaining balance between the actors has shifted from being in the favor of the IOCs in earlier times, and is now skewed in favor of the petroleum states where the percentages of government take range between 60 and 90 % of the total income from petroleum activities (Russell & Dawe 2013:347).

The IOCs have to go wherever the oil takes them, contrary to a manufacturing MNC who is mostly concerned with the costs of land and labor, which is a major factor for choosing a HG. Therefore, IOCs have a relatively high pain tolerance regarding terms of the contract (in this case the level of development intensity). This means that IOCs are more inclined to operate under less favorable conditions than MNCs in general. There are many ways IOCs and other traditional MNCs[8] can negotiate with a HG, but pulling operations out of the country is the final resort for both, if the contract is breached or an agreement not reached.

The element of political risk is also very important both for MNCs' and IOCs' choice of location. When deciding locations, IOCs and MNCs weigh their priorities of market size and growth against concerns regarding political stability (Stopford et al. 1991:143). In general, MNCs seems to be attracted to countries that are open to trade, exhibit low policy risk, offers well-developed institutions, and are already popular FDI destinations. Accordingly, the more a HG exhibits these traits, the better its bargaining position vis-à-vis the MNC. MNCs can improve their bargaining position by bringing to the table endowments such as capital, technology, organizational and managerial know-how, marketing networks, and employment opportunities, etc. (Jakobsen 2012:72-73; Moon & Lado 2000:94-98).

As mentioned earlier, IOCs cannot pick and choose their production locations to any large extent. Thus, IOCs cannot make location choices based solely on regime type. However, IOCs do emphasize political risk, so it is reasonable to assume that an IOC will have lower risk assumptions and exposure when investing in a regime exhibiting the traits mentioned in the previous paragraph. These assumptions should provide the IOCs with a longer time horizon of operations. Thus, in such a scenario IOCs may be more lenient towards accepting sub-optimal development intensity, and the HG's bargaining power, without attempting to counter balance. For the sake of our argument, this means that IOCs will more easily accept a low level of development intensity when investing in a democracy without threatening to, or actually pulling out. Regime type is an important aspect for comparative research on this topic, but as this thesis will analyze cases under one political regime, regime types will not be very important.

To return to Figure 1, the longer the time-horizon the IOCs can expect to operate within the province, the larger its win-set will be. This is because the decreased political risk perception increases the IOCs perceived time horizon, relaxing the IOCs fears concerning how long they will be able to operate in the country. If an IOC has a high political risk perception of investing in a country, it is expected that they would want to develop as much of the resource base as fast as possible, securing as much revenue as they can before pulling out or being evicted through e.g. nationalization or expropriation. If this risk perception is lower, the IOCs

[8] Even though IOCs are MNCs by definition, I differentiate between IOCs and other MNCs who have more traditional manufacturing bases. This is because the petroleum industry is inherently different from traditional manufacturing MNCs (e.g. textile or automobile manufacturers).

will on the other hand be able to foresee a long future of operation in the country, thus more likely to agree to the terms set by the government.

A petroleum state's bargaining power is highly affected by its estimated total petroleum potential[9]. The initial perception and assessment of the petroleum potential is dependent on the quality and availability of information, which can make this perception vary considerably. The perception of the petroleum potential can be based on wishful thinking (as in virgin/frontier areas) or on extensive documentation (like that of a mature province). It is important for the HG that this assessment is as objective as possible to avoid giving away resources to the IOCs at sub-optimal terms. After the initial exploration phase, proven reserves will have a larger effect on the bargaining position than unproven but expectations of reserves (Al-Kasim 2006:122).

Because of the initial uncertainty of reserves, a petroleum state distinguishes itself from manufacturing states, especially when it comes to bargaining. In ordinary manufacturing industries, *HGs* may have the upper hand in negotiations at the beginning. The HG holds the power to control and regulate the outcomes when a firm first enters the country, especially if the firm is in competition with other firms that it can be played off against (abstracting from scenarios where several states compete to attract one large firm, possibly resulting to a race to the bottom as mentioned earlier). The HG might lose influence after operations are established, as it will suffer the consequences of a possible MNC pullout (Stopford et al. 1991:26-27).

Conversely, in the petroleum industry, which is highly associated with risk, the *IOCs* may hold the initial advantage, as it often takes on the risk of initial and expensive exploration. However, the IOCs may lose the advantage after operations are established and assets are invested in fixed infrastructure etc. This is referred to as the "obsolescing bargain mechanism" (OBM) (Vernon 1977; Stopford et al. 1991:26-27). The literature largely recognizes that extractive industries are especially prone to being affected by the OBM (Jakobsen 2012:74). The reason for this change is that both the IOCs and the HG has very little knowledge of the resource potential in the initial stages of bargaining, as reserves have (usually) yet to be proved, it might even be wishful thinking that there are any at all. Even if seismic mapping shows interesting geological anomalies, it is not a direct proof that these are hydrocarbons. However, if initial drilling proves the existence of hydrocarbons, the bargaining power will

[9] I.e. how much petroleum the geological anomalies are thought to contain.

start to shift, and this shift will in some extent be dependent on the evaluated resource potential assessed after the initial discovery (Al-Kasim 2006:122-123, 202-203).

If a state exhibits proven reserves and if the estimated petroleum potential is high, the state has a better and wider range of policy options than in states where petroleum reserves are still a vision. Also, the foundation for the state's bargaining position will change over time, as information is gained through development of the sedimentary areas expected to hold hydrocarbons. Exploration activity will further enhance information about the estimated size of reserves (based on discovered and undiscovered deposits), adjusting it up or down, thus making the resource base variable both in space and time. This further means that the policy choices made for one field or province might not be suitable for others (Al-Kasim 2006:122-123).

One weakness with bargaining theory is that, although there is some consensus within the field, it still does not adequately explain why and when the balance and bargaining power shifts, why outcomes differ, or why and how the bargaining process gets started. One reason is that a state often has multiple conflicting objectives that are always shifting. Also, a state cannot be regarded as a rational actor in the game-theoretical sense, since its policy objectives seldom are fixed in a certain order of priority (Stopford et al. 1991:134-135). Thus, since there is no blueprint of which outcomes the bargaining relationship will produce, it is important to investigate how it can affect development intensity in a petroleum province.

This thesis proposes a new way of investigating bargaining outcomes in the petroleum industry, in the form of a government's ability to influence the development intensity. In the following section, the creaming curve is presented and discussed as to how it can be analyzed for evidence of government influence over development intensity.

2.4 The creaming curve

The creaming curve is a very simple graph, showing a curve that illustrates the accumulation of resources over time (or how much petroleum has been booked), based on discoveries by wildcat wells drilled. The creaming curve should essentially reflect that the size of discoveries should diminish with advanced exploration (Alveberg & Melberg 2013:32). This is because the IOCs are generally capable of finding the largest fields early in the exploration phase, and the smaller ones in progressively later stages (Meisner & Demirmen 1981:3).

As seen in Figures 3 through 6, the X-axis shows the number of wildcat wells in order of their completion, and the volume discovered by a wildcat well is then plotted as a cumulative or aggregated value on the Y-axis, showing how much petroleum has been discovered over time. This graph shows how the area in question has been explored. A steep increase in the curve indicates large discoveries from a single well or that there have been many smaller discoveries from several wells (visible in Figure 5). If the curve is gradual it means that there have been few small discoveries made or that there has been a longer period between discoveries (Alveberg & Melberg 2013:32).

Essentially, the curve shows the size of each discovery, increasing every time a discovery is made. This way, the curve either increases or flattens, but it will never decline, as the aggregated amount of discovered petroleum can never decrease. The most intuitive interpretations of the creaming curve will attribute deviations from the 'optimal development intensity', discussed in section 2.6, to technical or economic variables. We will however see that after controlling for these variables, government influence can explain the slope of the creaming curve.

The curve in Figure 3 is smoothed. The smoothed curve shows that the expected accumulation of resources over time (ref. booked resources) is thought to follow a logarithmic function: sharp initial growth that dissipates over time. The curve will never drop, because it only shows the accumulated size of discovered petroleum. It should be noted that the initial

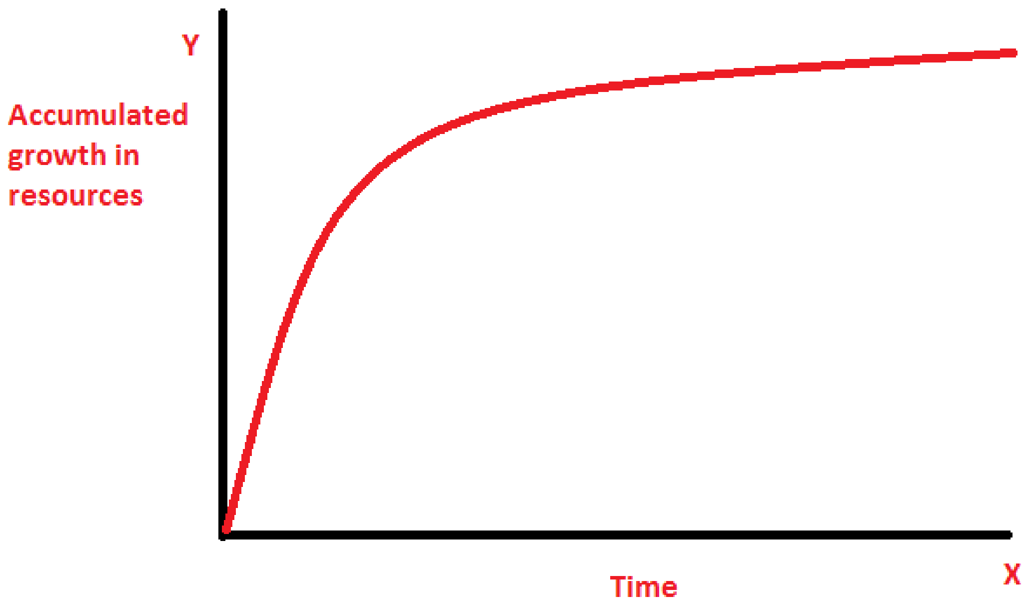


Figure 3 'Optimal development intensity' curve (Source: author)

stages of the creaming curve also represent a geological learning curve. This learning curve (often represented by smaller discoveries at the very beginning of the slope) is a result of the initial lacking understanding of the geology as well as mastering technical and operational procedures related to exploration in the particular area (Al-Kasim 2006:200-201).

Thus, it is expected that there may be a set of small discoveries at the very beginning of each creaming curve, but that the order of discoveries by size still will be affected by government influence. The reason this learning period is not included in Figure 3 is because the underlying assumption for this figure is that there are no uncertainties and perfect information.

The slope of the creaming curve is in many ways determined by a ranking system or appraisal scheme applied by the IOCs, where the geological prospects are ranked in accordance with the expected profitability of each prospect as poor, promising, or somewhere in between. The basis for this ranking is the available information on the particular prospects and the experience gathered from similar areas. The evaluation of each prospect is continuously updated as new information is gathered (Meisner & Demirmen 1981:3).

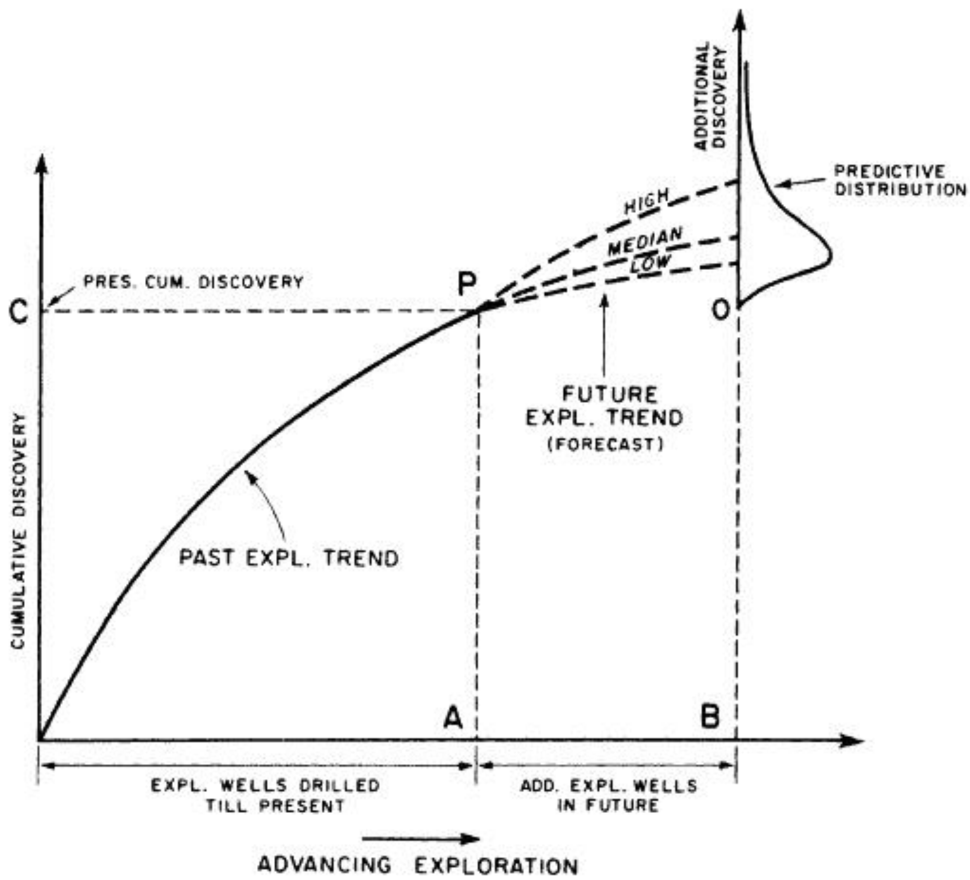


Figure 4 Forecasting future growth in resources (Meisner & Demirmen 1981:2)

Figure 3 is a counterfactual depiction of the assumed optimal sequence in booked resources. As it says on the X-axis “accumulated growth in resources” means how much petroleum has been discovered over time. Figure 5 provides a more realistic picture of the creaming phenomenon. Figure 4 illustrates the creaming curve’s intended use is forecasting future resource growth (through a Bayesian procedure), based on the evaluated petroleum potential of the province (Meisner & Demirmen 1981:1). The predictive distribution shows, that with extensive exploration the chance of discovering large fields diminishes significantly.

In accordance with Mohn & Osmundsen (2006) this thesis will measure development intensity through exploration activity, as it is an easily interpreted activity measure. However, contrary to Mohn & Osmundsen, this thesis will employ the creaming curve, or sequence of discoveries, as the main subject for analysis over the amount of exploration wells drilled. The reason for this is that the creaming curve can control for factors such as oil price fluctuations and technology lag. It is necessary to control for these, as it will leave us with only political factors that can influence the slope of the curve. This will be further elaborated in section 2.6. The following section is a discussion on how petroleum discoveries are generated, through exploration activity.

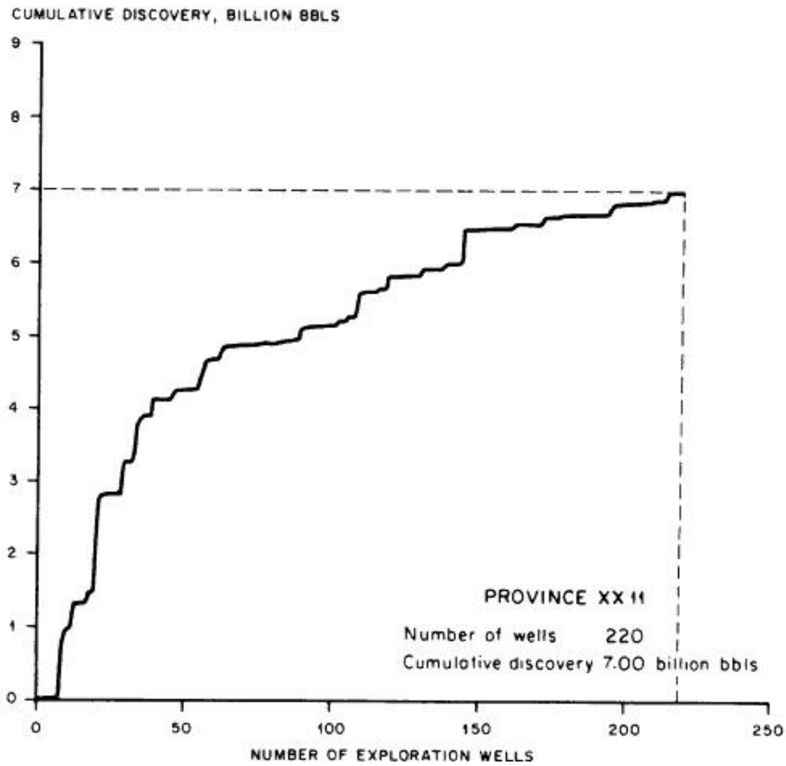


Figure 5 Creaming curve example (Meisner & Demirmen 1981:4)

2.5 Reserve generation and exploration

It is important to distinguish between two types of exploration activity. The first form of exploration activity is seismic mapping, which is far less expensive as it does not involve drilling or other activity on the seabed. Seismic mapping is quite easily performed by towing mapping equipment behind a designated vessel, which maps the seabed and its geological structures, possibly revealing geological anomalies expected to contain hydrocarbons. This creates the very foundation for drilling activity.

The other form for exploration activity is the drilling of a type exploration well called a wildcat well[10]. This type of exploration activity is directed at a discrete petroleum prospect, and exploration consists of a series of wells, each with a known cost. Also, each well will produce either a dry hole or a discovery of small, medium, or large size. This form of exploration activity usually involves high levels of cost and risk. The IOC is assumed to consider a drilling sequence of exploratory wells where the discovery probability is updated after each dry well, justifying the abandonment of exploration activities after a certain amount of dry wells (Smith 2014:141-142). If a wildcat well produces a discovery, appraisal wells are drilled to further assess the deposit before production wells are drilled.

When exploring for oil and gas, there is a law of ‘conditional probability’ to take into account. This law states that the probability of drilling a successful second well declines after initial failure. The size of the decline is conditional on the IOC’s belief in the resource base. If there was a low *geological probability* of finding oil and gas in the sedimentary area, the decline may be large. However, if the drilling test produces weak results due to low *technological probability* (or insufficient technological competence), the decline may be lower as the failure is attributed to that specific well and not the geology. The risk-perception of drilling a dry hole rises rapidly if the IOC has little confidence in the geological probability, and if the accuracy of the drilling technology is perceived to be good, the risk perception will rise even more rapidly (Smith 2014:142,146).

As an IOC explores a petroleum province, the technological probability is assumed to either improve or stay the same, while the geological probability will decline over time as the province is explored. This implies that the conditional probability is evaluated for each prospect before drilling ensues. Thus, conditional probability both explains the IOCs ability to

[10] In this thesis, exploration activity refers to this second type of petroleum exploration, unless otherwise specified.

detect the largest discoveries first as well as the expected timespan of the exploration phase in a petroleum province. It is not likely that any large petroleum deposit has been discovered purely by chance after the introduction of seismic mapping in the offshore petroleum industry. There can be instances where the technological probability of drilling a good prospect has been too low to produce a discovery at one time, but that this deposit has been discovered later, e.g. the Johan Sverdrup discovery in the North Sea. However, this does not mean that the deposit was discovered by chance, since there was knowledge of the prospect before the late discovery.

According to Mohn & Osmundsen (2006), the two primary sources of organic reserve growth (abstracting from acquisitions and divestitures) are: (1) exploration drilling, which is associated with high risks and high reward; and (2) capital investments and efforts to increase the recoverability of reserves in producing fields through improved oil recovery (IOR) and enhanced oil recovery (EOR) measures. The associated risks with IOR/EOR are lower than exploration activity, but so are the rewards. IOR and EOR measures are important for the petroleum potential of a petroleum province, since these methods can greatly improve the recoverability of the resource *in situ*. Delaying field discovery and development can be in the HG's interest if IOR/EOR technology is lagging and the HG wants to exploit the deposit more effectively (Smith 2014:140-157).

IOCs are profit-maximizing actors, seeking to increase the returns from both production and reserve generation. Therefore it is in the interest of the IOCs to discover the largest fields first, as they generate the most revenue, and that many fiscal systems allow for exploration costs to be carried forward, furthering incentives for exploration. A larger field can host more production wells, thus creating more revenue faster, which again enables the IOC to explore more.

Due to maturation of oil and gas reserves, license shares and other petroleum assets, exploration activities can develop into an autonomous profit generating activity, as it has in the Norwegian case (Mohn & Osmundsen 2008:306-307). The exploration decisions does not necessarily require future development and production, as any discovery is evaluated on its own merit, opening for a range of different strategies for further optimization of the value of the discovery. According to Mohn & Osmundsen (2008), exploration activities are not necessarily capital intensive, as all capital equipment are hired by the IOCs on the long term for these specific activities (ibid.). Based on the sections above, a theory of the 'optimal' and ‘observed’ development intensities is derived.

2.6 Optimal vs. observed development intensity

To be able to measure government influence on development intensity, it is necessary to establish expectations of what *optimal development intensity* would look like, and how this could be illustrated in the form of a creaming curve. For exploration activity to follow an economically optimal path (hence optimal development intensity), it is assumed that there would need to be perfect information, no uncertainty of future prices, no contractual obligations, no lags in exploration technology, and no regulatory constraints (Mohn & Osmundsen 2008:308). Of these factors, contractual obligations and regulatory constraints (and to a certain extent, information) are directly controlled by the state, whereas exploration technology can either be procured or developed by each actor on its own or in cooperation with each other. The uncertainty of future prices is generally very difficult to manage, as it is largely dependent on supply and demand.

Following the assumptions related to the costs of exploration activity found in Adelman (1962:18) and Attanasi (1979:310-311), exploration drilling is directed at the most promising prospects first, and the rest of the prospects in order of drilling priority. An IOC could rearrange this order at will, but inferring from the law of conditional probability, the most promising prospects will be drilled first because they exhibit the lowest geological risk and the largest probability of reward. Further the next most promising prospect will be drilled, then the third, and forth.

Consider, then, a petroleum province with the following characteristics: it is only subject to the price of oil and operating costs, there are no regulations or government influence, the petroleum potential is known through seismic mapping, and there is no lag in exploration technology. In this context, it is reasonable to assume that the creaming curve will take a logistic form and show: 1) a sharp rise in the early stages of the exploration phase (as the largest discoveries are expected to be discovered first); and 2) that the curve would peter out as the IOCs explore less and less promising prospects; until 3) the price of oil and the low expectation of remaining reserves no longer makes it commercially viable to do so. In such a scenario, the beginning slope of the creaming curve would look very much like the curve in Figure 3. I will call this the ‘optimal development intensity’ curve.

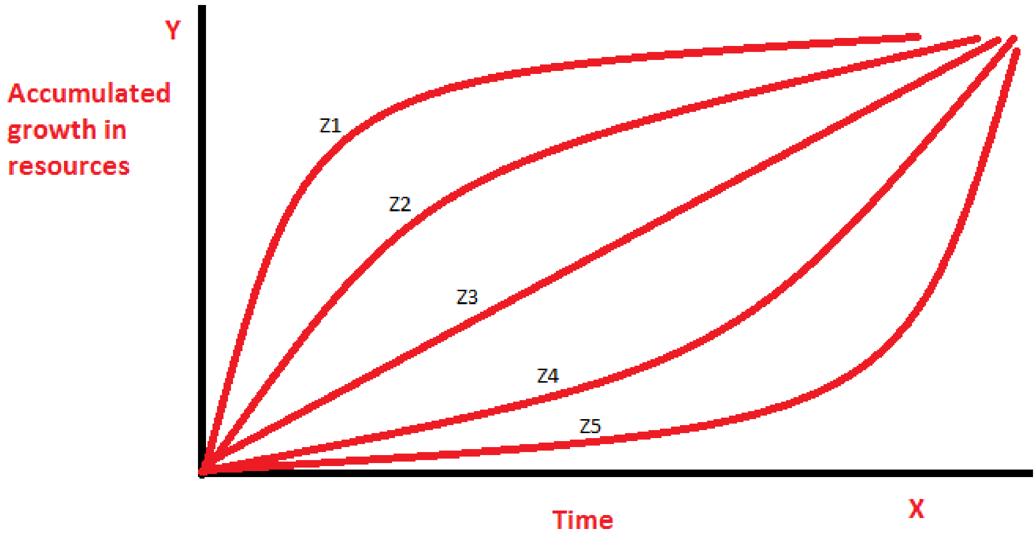


Figure 6 Development intensity outcomes (Source: author)

In Figure 6 we find a counterfactual depiction of the assumed possible development intensity outcomes by the sequence in booked resources. The most optimal outcome is marked as Z1 as we saw in Figure 3, and other sub-optimal outcomes are marked Z2-Z5. All outcomes assume that there are both large and small petroleum deposits in the province. Based on these possible outcomes, I create a scale ranging from Z1-Z5 corresponding to the outcomes in Figure 6, Z1 being the theoretically most optimal, and the development intensity becomes lower by each outcome. I also reiterate that the lowest level of development intensity is one not depicted in the Figure, i.e. no development intensity at all. In outcome Z2, there is more distance between the largest discoveries than in Z1, and Z3 shows even larger distance. In outcome Z4 and Z5, the smallest discoveries are made first and the largest at the end of the exploration phase, again differentiated by the distance between the large discoveries as in Z1 and Z2. Outcome Z1 is regarded as optimal, Z2 and Z3 as moderate, and Z4 and Z5 as low.

Figure 5 is an example of a creaming curve found in Meisner & Demirmen (1981), showing the actual accumulation of discovered resources in a petroleum province with low levels of regulation. This curve shows that small deviations from an optimal development intensity[11] path can occur even in lowly regulated petroleum provinces. The size of some of the later discoveries (although not nearly as large as the initial ones) provides signs of the industry's increased ability to locate new fields through technological advancements. However, these

[11] I will point out that it is theoretically possible to observe a Z5 development intensity level in an unregulated petroleum province. However, the chance of this happening is exceptionally small, as the probability of success in random drilling (which would be the precondition for such a scenario) is roughly equal to the ratio of the sum of the areal extent of all the hydrocarbon accumulations to the total area of the province (Meisner & Demirmen 1981:6)

discoveries have relatively small effects on the creaming phenomenon of diminishing field size with advanced exploration (Meisner & Demirmen 1981:3).

2.7 Hypothesis

To conclude this section I postulate a hypothesis based on the theoretical foundation presented above. The hypothesis (H1) states that:

> *(H1) If the observed development intensity deviates from the 'optimal development intensity', ceteris paribus, it is caused by government influence; if there is no deviation, there is no government influence.*

If the observed creaming curve deviates from the optimal development intensity curve after controlling for other relevant variables, we can expect that the deviation is caused by government influence. If we observe a deviation between curves, *ceteris paribus*, we have evidence that the government has influenced development intensity to accommodate for its political goals.

3.0 Methodology

In this chapter I firstly present the case study method, before presenting how we can measure government influence on development intensity in the petroleum provinces. Secondly, I will discuss how other theoretically relevant variables might affect the development intensity in the Norwegian case, and how to control for these. Thirdly, I will show how the NCS can be divided into three separate petroleum provinces, which I will then analyze as sub-cases. In this section I discuss what is special for each province and how their unique features control for other theoretically relevant variables. Fourthly, I discuss the application of time-series analysis on the sub-cases. Fifthly, I show how the empirical data have been treated and how the different graphs and histograms were created. Finally, I discuss the validity and reliability of the variables, the way they have been measured, and the replicability of the results.

3.1 Case study

I will combine two methodological approaches. The overarching method is a critical case study applied to the Norwegian petroleum sector. Using this method I show that no theoretically relevant variables, other than government influence, adequately explain deviations between 'optimal' and 'observed' development intensities in the Norwegian case. The second and subordinate method chosen is John S. Mill's "Method of Difference". This method will be employed to each case in order to compare variations between the 'optimal' and 'observed' development intensities between each of the petroleum provinces. As I will conduct a comparative time-series analysis of petroleum provinces within the jurisdiction of one specific state, the result will be effective control over the case. The reason for this is that the basic characteristics of the political regulatory regime remain the same across all provinces, while the provinces can vary with regards to physical characteristics (climate, water depths, etc.) and eventual policy choices special to each province. If we then observe deviations between the 'observed' and 'optimal' development intensities for all provinces regardless of physical variation, ceteris paribus, a causal relationship can perhaps be inferred between the political regulation and the deviations (Hancké 2009:68,73-74; Moses & Knutsen 2012:99-102).

I will analyze quantitative data (the creaming curves) in a qualitative manner, and I have deduced expectations of what an optimal development intensity curve would look like, in light of exploration theory. Since causation itself is not observable, we have to rely on counterfactual thought experiments. These experiments discuss what the 'observed development intensity' would look like if it had followed an optimal path, or if the deviations from this path had been caused by factors alternative to government influence. This is critical for inferring any causal relationship using this method (Moses & Knudsen 2012:58). By controlling for other variables, and examining provinces that have a low degree of internal physical variation, the counterfactual assumptions should hold. The counterfactual depiction of the assumptions constituting the 'optimal development intensity' is shown in Figure 3.

3.2 Controlling for theoretically relevant variables

In this section I will discuss how other theoretically relevant variables, that are thought to have an effect on development intensity, will be controlled. As stated in the previous chapter, it is important to thoroughly control for these variables, so that any remaining deviation can be attributed to government influence. I begin by discussing technical variables and operational conditions relevant for the NCS. I then turn to geological variables, before closing the section with a discussion of economic variables.

3.2.1 Technical variables

It is not easy to control for the continuous technological development that has happened on the NCS. The technical variables that are thought to have an effect on the development intensity are mainly related to challenging weather and climatic conditions, and water depths. First of all, it was necessary to develop installations that could handle the harsh weather conditions. These installations were at first upgraded versions of floating Gulf installations like the Ocean Traveler, being the first semisubmersible rig to drill on the NCS (Norsk Olje og Gass 2010). The most important role of technology on the NCS has been to secure optimal and environmentally friendly recovery of petroleum resources, and the Norwegian petroleum sector has maintained a very high environmental standard as compared to other petroleum states (Tormodsgard 2014:48,58).

Second of all, when water depths were a considerable challenge for establishing production platforms on the NCS. Establishing operations on the NCS were at the time the most challenging in offshore pioneering; therefore, concepts and procedures were constantly under development (Al-Kasim 2006:42-43). Initially, production was conducted from floating or semisubmersible platforms, and in the late seventies platforms were developed for production in the deeper parts of the North Sea province. The real challenge in production technology was building platforms that could remain stable under harsh weather conditions, especially during the winter (Al-Kasim 2006:42). Floating production rigs brought in from the Gulf of

Mexico evolved over time into the giant concrete structures known as Condeep (concrete deep water structure) platforms, and later floating production storage and offloading vessels (FPSOs). Concrete structures were already in use at the NCS by 1969 (the Ekofisk tank) (Norsk Olje og Gass 2010; Al-Kasim 2006:89), but the Beryl A platform is recognized as the first Condeep platform in the North Sea, being established in 1975 on the UK continental shelf (Offshore Technology 2015). The main reason for developing concrete platforms, as opposed to floating platforms, was the Alexander Kielland accident of 1980, which caused numerous casualties being the biggest accident in Norwegian petroleum history (Norsk Olje og Gass 2010, Al-Kasim 2006:89). However, floating platforms are in use today, for instance the Snorre platform in the northern part of the North Sea (Alveberg & Melberg 2013:92). How to control for climatic conditions is discussed further in section 3.3.

Exploration activity is not dependent on establishing fixed infrastructure, like platforms, because offshore exploration drilling is conducted from floating rigs such as drillships or semisubmersible rigs that are able to drill at water depths up to 3657 meters, or bottom supported “jack-ups” that are able to drill at 122 meters of water (Diamond Offshore 2014). Drillships have been in use since the late 1950s, starting with the CUSS 1 that was able to drill on 106 meters of water depths. Later, in 1965, a technological stage was reached where it was possible to drill below 182 meters, through the development of semisubmersibles like the Sedco 135. Ten years later, in 1975, the drillship Discoverer 534 was able to drill at water depths up to 2133 meters (Schempf 2007:112-113,130; Infield 2015).

The technology for exploration and the technology for development are largely considered independent from each other, seeing that the latter is dependent on establishing fixed infrastructure while the former is not. Inferring from the paragraphs above, it was technologically possible to explore all water depths and climates in the provinces before beginning operations. Therefore, any significant lag that could cause deviations between the optimal and observed development intensities is considered absent.

The reason the NCS cannot be examined as one curve, is that there is too much variation between the provinces. Not only does the climate get rougher the further north one goes, but the water depths also vary to a great extent. In the North Sea, the water depths in the southern parts vary from shallow depths of about 70 meters to depths of about 300-350 meters in the northern parts, at the Snorre and Troll fields. In the Norwegian Sea, fields are operated on at water depths of about 300 meters in the shallower parts to more than 1200 meters deep at the

Aasta Hansteen field in the northeastern parts. In the Barents Sea, petroleum is currently produced at water depths up to 420 meters (the Goliat field) (Alveberg & Melberg 2013:71,86,90,98,114). Because of these differences in water depths, as well as climatic conditions (as discussed in section 3.3), it is necessary to divide the NCS into petroleum provinces so that I can exercise effective control for technological conditions special to each province.

If discoveries were dependent on development technology, technological achievements such as sub-sea installations or deep-water drilling should create unexpected spikes in the discovery rate late in the exploration phase. For instance, in the Norwegian Sea there are blocks where the water depths reach 2000 meters and below, which is very deep. As we will see in the analysis, this is not the case. For instance, the Ormen Lange field, located in 800 – 1100 meters of water, took seven years before being approved for development. Another example is the discovery of the Troll II field, which it took an astonishing thirteen years to approve for development. In comparison, the Statfjord field was approved within two years of discovery (Alveberg & Melberg 2013:93,99,86). The fact that a discovery can be made one year, but not approved for production until thirteen years later shows that there is little dependence between these technologies. This is because a field will not be put into production before it is deemed safe to do so. In the time between discovery and approval for production, the technology necessary to safely produce at the location will be developed.

3.2.2 Geological variables

Hydrocarbons are generated by a chemical conversion of organic matter that has been deposited in sediments, which over time is deeply buried through geological processes. The organic matter is exposed to high pressures and temperatures and the sediments are converted into rock (like sandstone or limestone), and the organic matter into hydrocarbons (Taverne 2008:3-5). The geological conditions on the NCS are thought to be more or less the same, as most of Norway's petroleum resources formed in the Jurassic age, with oil reservoirs exhibiting good properties allowing high production rates per well. The quality of the reservoirs is good, generally having high pressure, good porosity, good permeability, and gives good recovery rates compared with other regions (Alveberg & Melberg 2013:11; Al-Kasim 2006:137; Norwegian Petroleum 2015D). There are of course variances in the geology within one region, as one deposit can be found in sedimentary layers deeper under the seabed than others, where temperatures, pressure, etc. vary. These variables are on the other hand thought to be more important for development technology.

3.2.3 Economic variables

As mentioned earlier, price fluctuations within the industry can create exploration cycles. These exploration cycles are thought to affect the development intensity in the latter stages of the exploration phase, where more or fewer prospects will become commercially viable depending on the price. As the exploring parties are usually able to find the largest fields first, the price fluctuations are not thought to have an effect on the early (and most important) stages of the curve. This is because the rewards from the largest discoveries almost always exceed the costs of developing them. Thus, by examining the creaming curves for separate petroleum provinces for evidence of government influence on the development intensity, price fluctuations are automatically controlled for in the early stages of the curves. I also point out that highly regulated tax environments, like the NCS, have a much lower long-term price elasticity than lowly regulated provinces like those found in the U.S. (Mohn & Osmundsen 2006:316).

3.2.4 Information

One of the most important variables to control for is information. If there are a given number of prospects, the explorer cannot properly rank these without knowing about all of them. In the Norwegian case, nearly all the data on the geology in the North Sea province had been gathered before the first licensing round in 1965, and in the Norwegian and Barents Seas before the opening of the 62nd parallel in 1980 (Al-Kasim 2006:203,26-27). Also, this information was made available for purchase to the IOCs in advance of the first licensing round of each province. Because of this, we can assume that both the IOCs and the Norwegian government had the necessary information base on the prospects for each province, before licensing began. The necessity for adequate information is further discussed in chapter 5.

3.3 Provinces

As mentioned in previously, this thesis will look at three different cases of development intensity on the NCS, by analyzing the separate provinces. By analyzing the development intensity for each province alone, I am able to control for other variables thought to affect the development intensity. The provinces involved here are the North Sea, the Norwegian Sea, and the Barents Sea.

To be able to measure the effects of government influence on the development intensity in a petroleum province, the province needs to be limited to a sedimentary area where drilling conditions are more or less the same. By drilling conditions, this thesis focuses on known technological challenges that limit the accessibility of the resource, like average water depths and climatic conditions. By separating the NCS into three separate petroleum provinces I can better control for water depths, maritime conditions, weather conditions, and geology. Of these factors, water depths and weather conditions are regarded as the most important to control for, because these are the ones that present the greatest challenges for establishing operations. This challenge was well known to the Norwegian authorities before they started allocating blocks in areas north of the 62nd parallel (i.e. the Norwegian and Barents Seas), where the water depths and weather conditions become exceedingly more challenging.

It is not possible to draw a sharp geographical line where the weather becomes immediately harsher, so the areas on opposite sides of the 62nd parallel will naturally experience much of the same weather. However, the weather in one province will on average be harsher than in the previous, the further north you get. Also, oil fields in the North Sea province are located on shallower waters than in the two other provinces. As the Norwegian authorities both withheld the areas north of the 62nd parallel, and the differences in conditions between these two provinces, this becomes a natural place to draw the line separating the North Sea province from the Norwegian Sea.

The Norwegian Sea and the Barents Sea provinces are separated at roughly the 69th parallel. This separation does not have to be as precise as the separation between the North and Norwegian Seas, because there are no blocks presently awarded in neither the Nordland VII (the northernmost exploration area in the Norwegian Sea) nor Troms II (the southernmost exploration area in the Barents Sea) exploration areas, which is the adjoining area of these provinces. Map A1 through A4 in the appendix shows the separation of provinces.

As petroleum operations were not commenced in the two northernmost provinces until after 1980, there is more data to analyze for the North Sea. As the start of the creaming curve also represents somewhat of a learning curve, I am able to better control for initial technological learning, as the curve is confined to a single province. Thus I expect to see a few smaller discoveries in the initial stages of each creaming curve. The uncertainty of the commerciality and stability of the chalk reservoirs at Ekofisk led to a three year test production phase conducted from the Gulftide “jack-up” platform, before moving on to drilling at the deeper waters at the Statfjord field in 1974 (Al-Kasim 2006:42-43,200-201). It is hence expected that the essential technological and geological learning for the NCS was completed after 1973, and that technological learning was then confined to understanding each field, but not the shelf itself. Further, I assume that there is a short but necessary learning phase for each of the other two provinces.

With the aforementioned variables controlled for, my a priori expectations are that if we observe deviation between the development intensities in all provinces, these would be caused by government influence.

3.4 Time-series

The provinces will be separately analyzed in a time-series, which starts when the first exploration well is spudded, and ends in 2014 where the data runs out for all provinces. By studying each province in time-series, we can better examine the sequence in discoveries. As discoveries are made over an extended period of time, it is important to analyze the provinces in time-series to see if a large discovery in a late stage of the curve could have been discovered earlier, looking back at available technology and similar discoveries. If there is a lag, such an occurrence could be justified by a previous technological challenge that has been overcome. However, if this was to happen and technology lag is properly controlled for, we have evidence of government influence delaying the discovery.

The starting points to the time series will vary, as exploration activity in the North Sea has been going on for longer than in the two other provinces. The empirical data available starts in 1965 for the North Sea, and in 1980 for the Norwegian and Barents Seas. Yet, this is not thought to be a problem, since exploration of a new basin, sub-basin, or play presents itself with new challenges, especially between provinces. When exploring for hydrocarbons, not all the previous experience will be relevant, which creates a new cycle of geological experience within each province (Al-Kasim 2006:200-201). In other words, each province presents itself with new challenges, unique to that province. This means that to a certain extent, petroleum operations in one province are independent from the others

3.5 Data

The data employed in this thesis have been gathered from Norwegian Petroleum’s web pages, and the data for the creaming curves have been received on request from the Norwegian Petroleum Directorate (NPD). Below, I show how these data have been treated and how the different graphs and histograms have been constructed.

3.5.1 Creaming curves

The values on the X-axis in creaming curves are normally the well sequence, showing equal distance between each well that is drilled. This gives a good insight to resource growth in the short term, but as this thesis will analyze three petroleum provinces over a long time period we need time consistency. The creaming curves provided by the NPD in its 2013 annual resource report show the creaming curves with time intervals varying in length (as shown in figures A1, A2, and A3 in the appendix), presenting a distorted view of the actual rate of growth in the resource base. This is because the distance between each data point is based on the number of wildcat wells drilled in the entire period, and not the time at which the well was drilled. By changing the values on the X-axis we should observe that the creaming curves become more stretched than the ones presented in the NPD's report.

The NPD has only included creaming curves in its 2013 annual report (Figures A1, A2, A3), while previous reports have illustrated resource growth with an ordinary and time-consistent graph, following a more linear direction as seen in Figure A4. There are two reasons that the Figure A4 is not suitable for my analysis of government influence on development intensity: 1) because it encompasses the whole NCS in one graph; and 2) because it does not clearly show the size of each discovery as well as a creaming curve does, nor the creaming phenomenon. This is important, because I want to be able to clearly observe each discovery, small and large, I want to be able to control for other theoretically relevant variables by analyzing each province on its own, and I want to observe the variance between the optimal development intensity and the observed development intensity, which is best viewed through the creaming curve because we can easily see the size and sequence of the discoveries compared with each other.

Recognizing that we need time-consistency to be able to say something about how government influence has affected the development intensity (measured in timing of the largest discoveries), I edited the creaming curves from the 2013 resource report to achieve this. Upon request, the NPD provided me with the data sets these curves were based on, allowing me to reconstruct the curves and make them time-consistent. However, these data encompass both oil and gas (unlike Figures A1, A2, and A3), and is thus stated in oil equivalents (o.e.). This is not regarded to be a problem, even though oil is most sought after. It is not easy to say anything about the state of the hydrocarbons before actually drilling a wildcat well, as seismic data has to be interpreted. The further development of the reservoir is on the other hand dependent on the type of hydrocarbon found. If the discovery consists mainly of gas, it is more dependent than oil on nearby infrastructure and distance to market.

The dataset received from the NPD also contain discoveries that fall within the NPD's "resource category 6", which are discoveries that are thought not to become commercial, even in the long term (NPD 2013:15). To develop these discoveries, substantial technological developments are needed, and the costs and oil prices have to justify commercial production, but that such changes are thought to be unlikely (ibid.). As the curve shows both gas and oil discoveries, I argue that this is of low significance due to the fact that the content of a prospect has to be proved through exploratory drilling. A small prospect can be proved commercial if it contains oil, but not if it contains gas. This is especially relevant for the Barents Sea province where the discoveries are smallest and fewest, as well as that the province mostly contains gas.

The new creaming curves (Figures 7, 10, and 13) have been constructed using Microsoft Excel. To make the new curves time consistent, it was necessary that each year interval be based on the same number of cells. This number was based on the year with the highest number of wells drilled. Since the data set did not include the date for each well drilled, only in what sequence, it was not possible to exactly place each well according to completion date. This is however not that important, since we mainly wish to see the outline and shape of the curve. Further, the data points were spaced out between the year intervals. When the Y-value increased from one data point to the next (dry well to discovery), these data points were placed close to each other to get the typical creaming curve look (vertical as opposed to oblique lines). Additionally, vertical lines were drawn manually to better mark each year along the X-axis. The green lines indicate a year where licenses have been allocated, either in numbered license rounds or in APA-rounds, the red lines indicating a year with no licenses awarded. The licensing system will be further discussed in section 4.1.

For chapter 5, Figure 16 was constructed displaying all three creaming curves. This was done in order to better compare the variance between the curves in a comparative context. This graph was based on the creaming curve for the North Sea, which has in some degree resulted in the two other curves being stretched. This happens because the distance between the years increases for the other two curves (based on the number of wells drilled per year). As the North Sea has both the record for most wells drilled per annum as well as the longest history of operations, this was the natural choice. This is not regarded as a problem because they still show the creaming phenomenon, even if the distance from year to year has increased. This makes the curves look longer, which suits us well for the comparative analysis intended.

3.5.2 License histograms

The histograms showing the number of licenses awarded each year, for all three provinces (Figures 8, 11, and 14), were constructed in Microsoft Excel, by rearranging and sorting the data in the downloadable Excel spreadsheet from Norwegian Petroleum's webpages (Norwegian Petroleum 2015B). The data in this spreadsheet was categorized mainly by province, showing each license awarded per round as a single unit. The licenses were manually counted, sorted after year, province, and which round they belonged to. Finally each license was placed into individual tables before constructing the three histograms, showing the number of licenses awarded each year by license type.

3.5.3 Discoveries vs. Wildcat wells histograms.

These charts show the number of wildcat wells drilled and the number of discoveries made each year in the chosen period. These charts were constructed in Microsoft Excel based on the data sets received from the NPD (NPD 2015B, 2015C, 2015D). To construct these histograms, each well and discovery was manually counted, sorted, and placed into individual tables, on which the histograms then were based. The number of wells in the North Sea was 674, in the Norwegian Sea 218, and finally the Barents Sea 99.

Figure A5 is a scatterplot, showing the linear relationship between discoveries and wildcat wells. The scatterplot was constructed from the data sets provided by the NPD (NPD 2015B, 2015C, 2015D). This scatterplot was also constructed in Microsoft Excel using the scatter plot diagram tool. The number of wildcat wells was entered for the Y-axis and the number of discoveries on the X-axis.

3.5.4 Maps

Maps A1, A2, and A3 were taken from the NPD's FactMaps by screenshot. Unfortunately, to get the whole province in the screenshot, I had to scroll so far out that the names of the discoveries were not included. Therefore, the names were manually added, after importing the screenshots to the document.

3.6 Validity

The internal validity of these data is thought to be good, as I control for theoretically relevant variables in as good a way as possible. Also, the experimental methodological design is regarded to give a high level of internal validity (Moses & Knutsen 2012:58,101-102). There is of course the possibility that some technical aspects are simplified, or other unknown variables omitted. However, the variables controlled for in this thesis are regarded by the literature as the variables thought to have a direct effect on development intensity and petroleum activity levels. Thus, the findings in this thesis can with reasonable certainty be regarded as the cause between government influence and development intensity.

The external validity of this thesis is also regarded as good. Because of the solid theoretical and methodical framework presented, the procedure should be applicable to other offshore petroleum provinces. As the data employed is also quantitative and available on request, the replicability of the figures and results should be fairly easy. Generalizability of results are one of the difficulties concerning the case study, as examining one single case only yields limited results (Moses & Knutsen 2012:133). However, as I am testing a method for measuring government influence on development intensity, it should be transferrable across cases.

As the theoretical foundation in this thesis should be applicable to most offshore petroleum provinces, there is not necessarily any selection bias to this thesis. The Norwegian case was selected due to practical reasons such as the high level of transparency provided by the Norwegian authorities, familiarity with the language and political climate. Other than this, there was little *a priori* knowledge on the Norwegian petroleum industry, or the government influence over it.

3.7 Reliability

There is not thought to be any problems with over-determination, because of the low number of variables measured, as well as studying three cases within one case. Also, the separation of provinces yields separate creaming curves that are independent from each other. This gives us a broader set of cases to analyze, which can be helpful in avoiding over-determination. On problems of autocorrelation, the actors involved in bargaining in each of the three cases are expected to be largely the same group of IOCs. This is because the Norwegian authorities allocated licenses to the IOCs with the best expertise and technological capabilities, and was not based on monetary bidding (Al-Kasim 2006:242). However, as each province is independent from the others, auto-correlation is not thought to be a problem. It is possible that there are other unknown variables that can affect the development intensity, but that these are not biased in one direction and can cancel each other out.

The theoretical and methodological frameworks presented in the previous chapters will be applied in the subsequently, in the analysis the creaming curves for the NCS provinces.

4.0 Empirical Analysis

In this section I examine the creaming curves for the three Norwegian petroleum provinces. By separating the NCS into three different provinces I hope to control for technical variables that can distort the requisite creaming curves. As the climatic conditions and water depths vary greatly across the NCS, I isolate each province to show how the development intensity in that province has been affected by political factors, rather than technical factors. I also assume that there is a learning period in each province, and that this period is over after the first few discoveries are made.

Each year on the curve is marked with a line, the red lines indicating a year where no licenses were awarded, and the green lines show years where licenses have been awarded. In this chapter, I start by presenting the Norwegian licensing system, and how licensing policy can affect the development intensity. Although this is a bit awkward, as the license system is an integral part of the independent variable, I feel it necessary to present the reader with the necessary information for how licenses have been allocated in the Norwegian case. The intention is to make it easier for the reader to understand the presentation of the variation in the dependent variable. Following this section, I analyze the curve for each province, discussing its shape and the discoveries that affect its slope. Although the information in this chapter may seem overwhelming to the reader, it is essential for showing how each discovery can affect the slope of the curve. By thoroughly analyzing the location and water depths of the discoveries we can be more certain that the physical variation within each province is within the prerequisite parameters.

If we, ceteris paribus, observe a creaming curve that follows what is regarded to display optimal development intensity, we can assume there is no evidence of government influence on the dependent variable. If, however, we observe a curve that deviates from this optimal path, we can assume that this is caused by government influence, as other explanatory variables should have been adequately controlled for. I also incorporate figures showing the number of licenses awarded for the entire operating periods, as well as figures showing discoveries made and the number of wildcat wells drilled for selected periods of interest. These figures are included to help us interpret the slope of the curves.

4.1 The Norwegian licensing system

Before discussing the development intensity levels, the Norwegian licensing system is presented. The reason the licensing system matters in the Norwegian context is because it has been the main instrument of government influence, employed to control the level of development intensity by withholding acreage containing promising prospects. This information is important for understanding the basis for exploration activity in the Norwegian case.

Early on, the NCS was divided into equally sized blocks as a basis for where an IOC could apply for a license. Licensees can be awarded to small or large acreage within one block, or straddling several blocks, based on their application. The licensee is not allowed to conduct petroleum activity outside the awarded acreage. Also, in the past, the licensing system has been constructed so that the state would get back acreage left unexplored or undeveloped, a regulatory measure called the relinquishment rule. According to this rule, IOCs have to abandon acreage one quarter at a time, so that after nine years, the state will recover half the area first granted (Al-Kasim 2006:15-16).

The Norwegian licensing system today consists of two main types. The first type is the 'numbered' licensing system. These licenses are allocated in the least explored, or frontier areas, on the NCS. In these frontier areas, the geology is less known, there are greater technological challenges, and consequentially more uncertainty about discoveries. However, since these areas have yet to be explored, they can potentially host large undiscovered petroleum deposits[12]. In these licensing rounds, the IOCs are initially invited to nominate blocks for allocation, which are then assessed by the authorities before the announcement is submitted for public consultation. The nominations can be fully disregarded by the authorities, but are often adhered to. Also, the IOCs are not obliged to bid on the blocks they have previously nominated. The nominations were especially important for the Norwegian authorities in the 1960s, because they gave the government an indication of the blocks that showed the most promise, but it was also important for the IOCs as they were given the opportunity to nominate blocks they were especially interested in (Norwegian Petroleum 2015A; Al-Kasim 2006:208).

After the government announces the licensing round, IOCs apply for licenses separately or as a group. The authorities then either orchestrate or approve the composition of each license group, to ensure that the IOCs with the best competence are responsible for the development. This concerns both the numbered license system and the APA-system presented below. The numbered license system was the only system used until 2003 when the Norwegian

[12] A petroleum deposit refers to a prospect where petroleum resources have accumulated in source rocks.

government introduced the APA-system (awards in predefined areas) (Norwegian Petroleum 2015B). Also, acreage has sometimes been awarded in addition to previous rounds, several decades after its end. For instance, the first license in the 18th license round was allocated in 2004, while it took ten years before the last license in that round had been awarded (Norwegian Petroleum 2015B).

The APA-system and its forerunner, the North Sea awards (NSA rounds, introduced in 1999), are the second type of license system. These are awarded in mature areas to secure the development of marginal and time-critical resources adjacent or close to existing or planned infrastructure. In the APA-system, IOCs can apply for licenses on all acreage in the predefined area not already covered by a license. The expansion of the APA-area follows the maturation of newer acreage, but no acreage is withdrawn from the already matured area. The APA-areas are shown by the red lines in Map A1. The authorities submit expansion proposals for public consultation, and APA-rounds have thus far been held annually since 2003. The reason for establishing this second license system has been to prove and recover resources in mature areas before the existing infrastructure is shut down or removed. If discoveries are made in mature areas *after* infrastructure has been shut down or removed, development of these discoveries might not be economically justified (Norwegian Petroleum 2015A).

Within these two systems there are two different sub-types or license types: 1) exploration/reconnaissance licenses, and 2) production licenses. The exploration license gives the licensee the right to explore for petroleum, but not to develop any eventual discovery. Nor does it give exclusive right to the areas in which the exploration license was granted when production licenses covering the area are awarded. The production license gives exclusive right to exploration and development of petroleum deposits within the given area (Taverne 2008:227-229; Al-Kasim 2006:203).

To bring us back to the first paragraph of this section, it is important that we know the difference between these two licenses, as these are quite different in regards to the potential development intensity. As the APA-licenses are only awarded in predefined and mature areas, close or adjacent to existing or planned infrastructure, the chances of making large discoveries are small. However, the numbered license rounds are thought to have a much better chance of uncovering large discoveries. The relationship between these two types can be regarded as a way to politically control the activity level, by allowing for the development of marginal resources with the APA-system, and allowing for large discoveries with the numbered system.

Large discoveries beget a high activity level (as it often requires more wells and infrastructure to develop it efficiently), but the activity level can be complemented by developing several time-critical and marginal resources.

As it has been implied thus far, the number of licenses issued is important. However, one issue that may be just as important is the amount of acreage awarded in each license round (Figure A6). It has been generally been normal to award small amounts of acreage in numbered rounds, and much larger amounts in APA-rounds. As I am mostly interested in how *much* of the province is open for exploration, rather than how many IOCs that are allowed to explore, information on the amount of acreage awarded is very interesting. Basically, few licenses may be awarded, but the exploration acreage awarded may be large, and vice versa. The amount of acreage awarded in numbered rounds is important as the more exploration acreage is awarded, the larger the chance of making a large discovery. Alas, as the information how much acreage has been awarded for *each province* is not readily available, rendering me incapable of employing such data in my analysis. I will therefore try to compensate by arguing that the larger the amount of numbered licenses awarded, the larger possibility of a big increase in the creaming curve. *A priori*, it is most likely that numbered licenses are the ones that will influence the development intensity the most; as they are the most regulated and have the best chance of discovering the largest deposits.

It is also necessary to point out that one can expect there to be a certain time lag between the allocation of the license and a possible discovery. Equipment has to be moved around, drilling targets assessed and executed, and drilling samples have to be evaluated before a discovery will be announced. One case where such time lag arose is the allocation of the license on the Statfjord acreage, and the year that passed until the Statfjord field was discovered. However, I expect that the timing of the completion of a wildcat well the discovery produced correspond with each other.

4.2 Petroleum provinces

Following, I analyze the creaming curves for each of the three Norwegian petroleum provinces in a time-series, discussing the discoveries and slope of each curve. Also, the analysis for each province includes a histogram showing the number and types of licenses awarded for each year, as well as a histogram showing the number of discoveries and wildcat wells drilled in certain periods. These histograms will be employed to help interpret the creaming curves. First I discuss the North Sea province, then the Norwegian Sea province, and finally the Barents Sea province. The information on the discoveries on the NCS is gathered from the NPD's "FACTS 2013" report (Alveberg & Melberg 2013), from the NPD's FactPages online (NPD 2015A), and from the NPD's FactMap (NPD 2014B). This information is then structured after when each field was discovered to give us a chronological rather than alphabetical overview (as in Alveberg & Melberg 2013), improving our understanding of when and where the discoveries were made. I analyze the location and water depths of the discoveries to further discuss if the sequence has been affected by either technical challenges limiting operations (e.g. discoveries on exceedingly deeper water or further and further north), or by strong licensing restrictions within the province (e.g. limiting exploration activity to small areas within the province).

To make it easier for the reader to follow the information in the subsequent sections, Map A1, A2, and A3 have been added to the appendix, illustrating the location of the most important discoveries. These maps are screenshots of the NPD's FactMap (NPD 2014B). The names and arrows indicating each field have been added by the author. Also, to make them easier for the reader to process the information in the analysis, each of the discoveries discussed have been marked in the relevant creaming curves.

4.3 The North Sea Province

As stated earlier, the North Sea is the Norwegian petroleum province with the longest history, and for our purposes, the analysis starts in 1965 at the time of the first licensing round. Because of the large number of discoveries in the North Sea and the long time frame, I am not able to analyze this province to the same detail as the other two. This is not regarded as a problem, since I will focus the analysis of the curves on the discoveries most significant to their slope. Information on the location and water depths of each discovery will later be employed to show the randomness of field discovery within each province, from north to south and between shallow and deep waters. If technology has had a lot to say for field discovery, it is expected that the water depths would increase for each discovery, and that they would move gradually northwards.

As I stated in the previous chapter, the initial drilling period in the North Sea is regarded as a geological and technical learning period, which ends in 1973. The discussion of the period before 1973 is meant to give a descriptive perspective as to why this learning period was necessary. This period was also a learning phase for the Norwegian authorities in which they formed their infant petroleum administration.

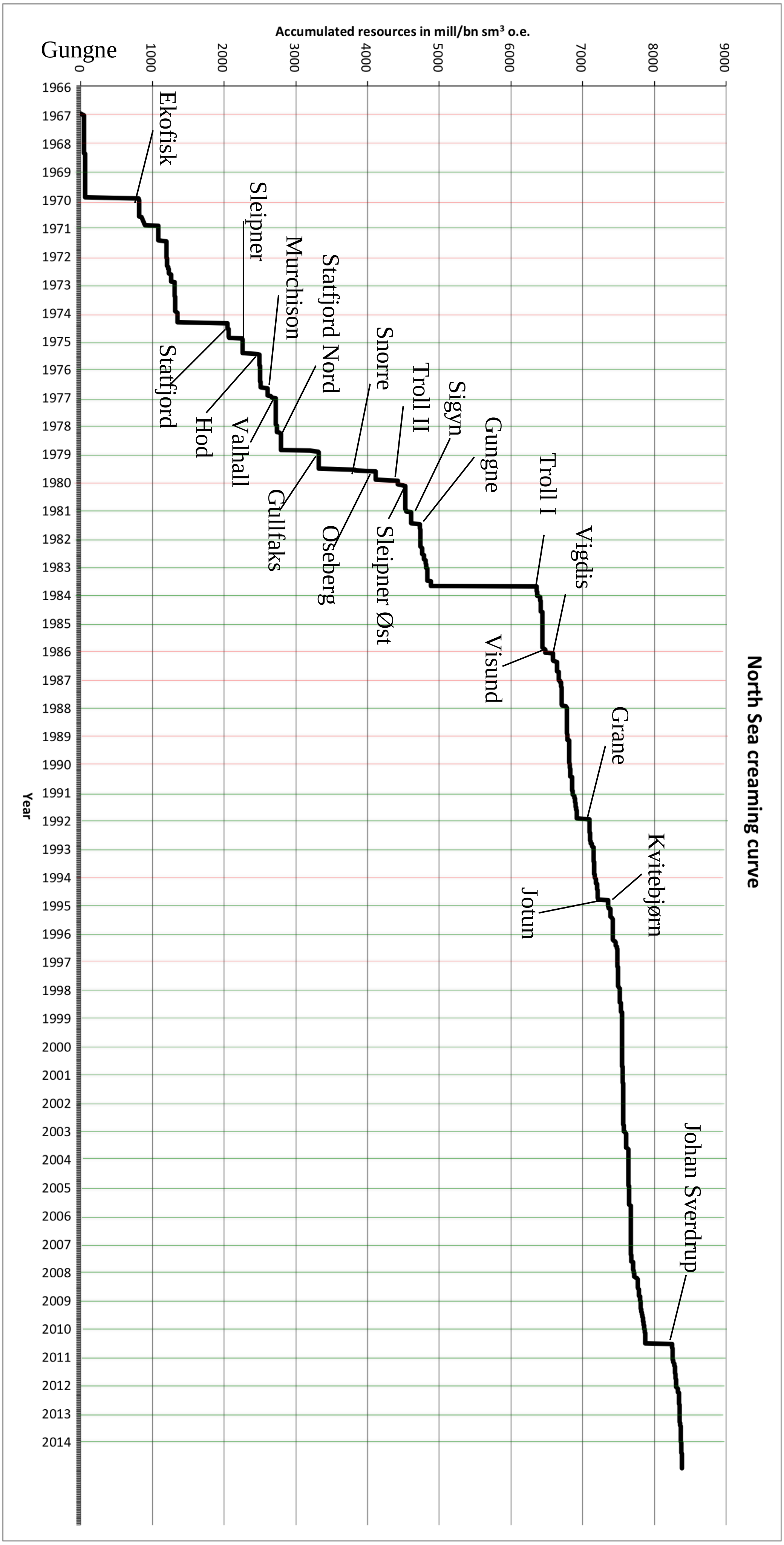


Figure 7 North Sea creaming curve (NPD 2015B)

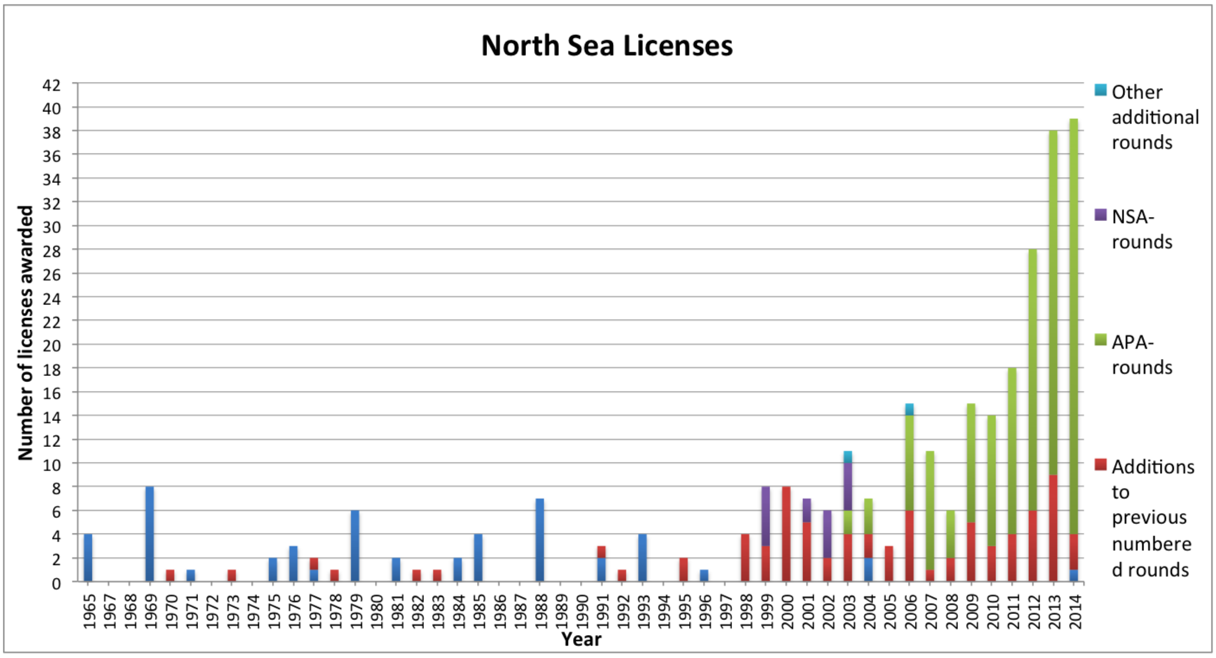


Figure 8 Licenses awarded in the North Sea (Norwegian Petroleum 2015B)

In the following analysis I examine the curve in five-year intervals as this delineation of periods suits the shape of the creaming curve well. If the development intensity has followed the optimal path, we would expect to observe that the largest discoveries in the province are grouped together early in the curve, after the completion of the learning period.

The first glance at the North Sea creaming curve reveals that this is not the case. Had the curve followed the optimal path after the end of the learning period, we should expect to observe a subsequent decrease in discovery size. This is however not what we observe. What we see in Figure 7 is more of a staircase-like shape to the curve, each step looking like a creaming curve on its own right (e.g. between 1970 and 1974, between 1974 and 1979 and so on), before it peters out gradually from 1983 onwards. This gradual flattening of the curve is expected, but we do however observe significant and unexpected spikes in 1991, 1994, and 2010.

4.3.1 1965 – 1973: The learning period

In the first licensing round in 1965, the Norwegian government offered 278 blocks in the North Sea, covering about 15% of the whole NCS. This has also been by far the greatest number of blocks offered by the Norwegian authorities (as seen in Figure A6). The reason for offering such a large amount of blocks was the Norwegian authorities' inexperience and lack of expertise in assessing the petroleum prospects, as well as attracting investment from IOCs. This led them to be somewhat lenient regarding the terms in the first licensing round. After negotiations, the first round finally ended with the allocation of 78 blocks spread out on four licenses (Al-Kasim 2006:17-18; Norwegian Petroleum 2015B).

As we can see in the creaming curve above (Figure 7), the first licensing round did not result in any major discoveries, despite the large acreage awarded. The only discovery was the Cod field in 1968, which gave the IOCs the much-needed encouragement to establish operations and further investments on the NCS. Also, this discovery gave the Norwegian government the encouragement to establish its own petroleum administration. The optimism sparked by the Cod discovery did however fade gradually, which resulted in an urgent second licensing round, lasting from 1969 to 1971. This second round resulted in the allocation of 13 new blocks, spread out on ten new licenses to the same IOCs that were awarded licenses in the first round (Al-Kasim 2006:14,20; Norwegian Petroleum 2015B). As we can see from the creaming curve, the first large discovery in the North Sea was made in the end of 1969, and was named the Ekofisk[13] discovery. Besides this discovery, the other discoveries in these two licensing rounds are small, which is expected in the learning phase. The Cod and Ekofisk discoveries were made in the shallow waters of about 70 meters in the southernmost part of the province. The lack of discoveries despite the large acreage awarded in this round can be attributed to the IOCs lack of knowledge of the shelf.

4.3.2 1973 – 1978

It took four years before new exploration acreage was awarded in the province. The next licensing round in 1973 is called the extraordinary licensing round, in which only two blocks were allocated (Al-Kasim 2006:28; Norwegian Petroleum 2015B). As we can see in Figure 7, after the Ekofisk discovery, there were several small discoveries before the next large increase in 1974. This new increase is the Statfjord discovery. The Statfjord field was located far north in the North Sea adjacent to the UK border, and on water depths varying between 130 to 305 meters (Kirk 1980:96).

After the Statfjord discovery we can observe that the curve starts to peter out, exhibiting a number of medium and small sized discoveries until the curve abruptly increases again in the end of 1978. The discoveries in this flatter stage are the Sleipner and Hod fields in 1974, the Murchison, Valhall, and Gudrun fields in 1975, the Statfjord Øst and Ula fields in 1976, and finally the Statfjord Nord discovery in 1977. If the shape of the curve could be explained by the discovery of fields adjacent to each other, or exploration activity restricted by water

[13] The most significant discoveries in all three curves are explicitly marked in Figure 16.

depths, we would expect the following discoveries to be located close to the initial large discovery (in this case the Statfjord discovery). Of these discoveries the Murchison, Statfjord Øst, and Statfjord Nord fields are adjacent to the Statfjord field, and lie respectively on 150, 159-190, 250-290 meters of water depth. However, the Sleipner and Gudrun fields are located centrally in the province, and the Hod, Valhall, and Ula fields lie in the southern part of the North Sea. These discoveries lie on 110, 110, 72, and 70 meters of water depth, respectively (Alveberg & Melberg 2013:80,84,91,94,95,101,103,115; Mair, Matheson, & Applebee 1987:628). Also, we can see that the discoveries that were made in other parts of the province were made in between the discovery of the Statfjord field and those adjacent to it, meaning that exploration activity was not restricted to the Statfjord area before moving on to other parts of the province.

4.3.3 1978 – 1983

Although not clearly observable in the creaming curve, the spike in 1978 is the combination of the Gullfaks and Gullfaks Sør discoveries, and the larger spike in 1979 is the combination of the Oseberg and Snorre discoveries. The second spike in 1979 is the Troll II discovery[14]. After the Troll II discovery, we again observe that the curve peters out, until the Troll I discovery in 1983.

The Gullfaks and Gullfaks Sør fields are located on water depths ranging from 130-220 meters in the northernmost part of the province. The Oseberg and Snorre fields, also located in the northern part of the province, lie on water depths of about 100 meters and 300-250 meter respectively. The Troll II field is located north in the province on a water depth of about 340 meters. To illustrate the time it can take between discovery and development, the Troll II field was discovered in 1979 but not approved for development by the Norwegian parliament (the Storting) until May 1992, and came subsequently on stream in September 1995. The areas where the Troll and Snorre fields have been discovered are also the deepest points in the North Sea, the greatest water depths explored since the Statfjord discovery in 1974 (Alveberg & Melberg 2013:77,92,99; NPD 2014B).

As I mentioned at the beginning of this section, the Troll II field is the final spike before the curve again peters out. This time, the discoveries are smaller than in the two foregoing steps. Figure 8 show that although there were annual licenses awarded in the third licensing round,

[14] The data provided by the NPD only include the sequence of wildcat wells and the discovery size in "o.e." (oil equivalents). This means that it is very difficult to pinpoint the specific identity of each discovery.

lasting from 1974 to 1978, there were few licenses awarded. In 1979 we can see that seven licenses were awarded in the fourth licensing round, almost as many as the four previous years combined, and the second highest number of numbered licenses awarded in one year on the NCS. As we can see by comparing Figures 7 and 8, the curve starts to peter out yet again, while the number of licenses remains approximately within the same levels as in previous years. The curve abruptly increases again in 1983, which is signified by the single largest discovery on the NCS, the Troll I field.

As for the flattening of this step in the curve, some of the smaller discoveries were found in other areas of the province such as the Sleipner Øst, Gungne, and Sigyn discoveries centrally in the province, in 1981 and 1982, on water depths ranging from 70-83 meters. The rest of these small discoveries were made in the northern parts of the province (Alveberg & Melberg 2013:78,80,89,90,92; NPD 2014B).

4.3.4 1983 – 1988

Troll I was found in the same area as the Troll II field, but was not discovered until 1983. The Troll field (which includes both discoveries) is the largest discovery on the NCS and the largest offshore gas field in Western Europe and among the largest in the world. As these fields are adjacent, we should expect them to be discovered quite close together, not four years apart (Alveberg & Melberg 2013:98; Al-Kasim 2006:67,79,245).

After the Troll I discovery we can observe that the curve peters out again, exhibiting a set of small discoveries in the following years. These discoveries are spread out over the province, but of these discoveries the Vigdis and Visund fields discovered in 1986 were found at the deepest water depths (280 and 335 meters respectively) north in the province, while the rest were found in shallower waters ranging between 70-200 meters (Alveberg & Melberg 2013:73,74,96,97,103,105,106,118,119).

4.3.5 1989 – 1994

As the 1980s come to an end, the slope of the creaming curve starts to exhibit the traits associated with maturity of a petroleum province, where the large fields have all been found and we are left with successively smaller discoveries until the curve gradually flattens. However, in 1991 and in 1994 we see two new and unexpected increases in the curve. These discoveries are, respectively, the Grane field and the combination of the Jotun and Kvitebjørn fields (which are not distinguishable in the curve). According to theory, we would expect to observe these discoveries at an earlier stage of the curve.

The Grane field was discovered at 128 meters water depth centrally in the province, under a production license awarded in the first licensing round in 1965, but the first wildcat well was not drilled until 1991 (NPD 2015A; Alveberg & Melberg 2013:76,81,82). At first, it is not easy to understand why it took so long before the Grane field was discovered, especially because it is so close to the Balder field (NPD 2014B), which was discovered in 1967 (NPD 2015A). This is because it is one of the few significant discoveries delayed by technology lag on the NCS. This is further discussed in section 5.1 in the following chapter.

The Jotun discovery was made at a water depth of 126 meters in 1994, 25 kilometers north of the Balder field in the central part of the North Sea. The field was discovered by Esso in an attempt to test the occurrence of hydrocarbons in the sedimentary layers of the lower Jurassic Statfjord formation and the Paleocene Heimdal formation. The license covering the area in which the Jotun field was found was added to licensing round 2-A, granted in 1994 (NPD 2015A). This field was discovered in an already well-explored part of the North Sea.

The Kvitebjørn field was discovered in 1994 on about 190 meters water depth in the northeastern part of the North Sea, close to the Valemon field discovered in 1985 (NPD 2015A; NPD 2014B). This is another example of the Norwegian licensing policy of awarding small acreage for each license within one block, which can result in discoveries like the aforementioned ones. However, it is important to point out that it is not always easy to interpret seismic data, which can result in distorted perceptions of prospect size, like those mentioned above, and more importantly like the Johan Sverdrup field that I discuss in the following section.

The reason why the Jotun and Kvitebjørn fields appear as one is because both were discovered only one month apart towards the end of that year, making the increase in the curve look like one discovery (NPD 2015A). This is however not thought to be a problem for the analysis, because the sizes of the discoveries were large enough to produce an unexpected rise to the curve this year even if they were further apart. As the curve peters out for an extended period this time, it is not as interesting to discuss the location of these smaller discoveries.

4.3.6 1995 – 2014

As the creaming curve now peters out over a long period, I discuss these final years in one bulk. As we observe, there are no longer any large discoveries made in the North Sea (with

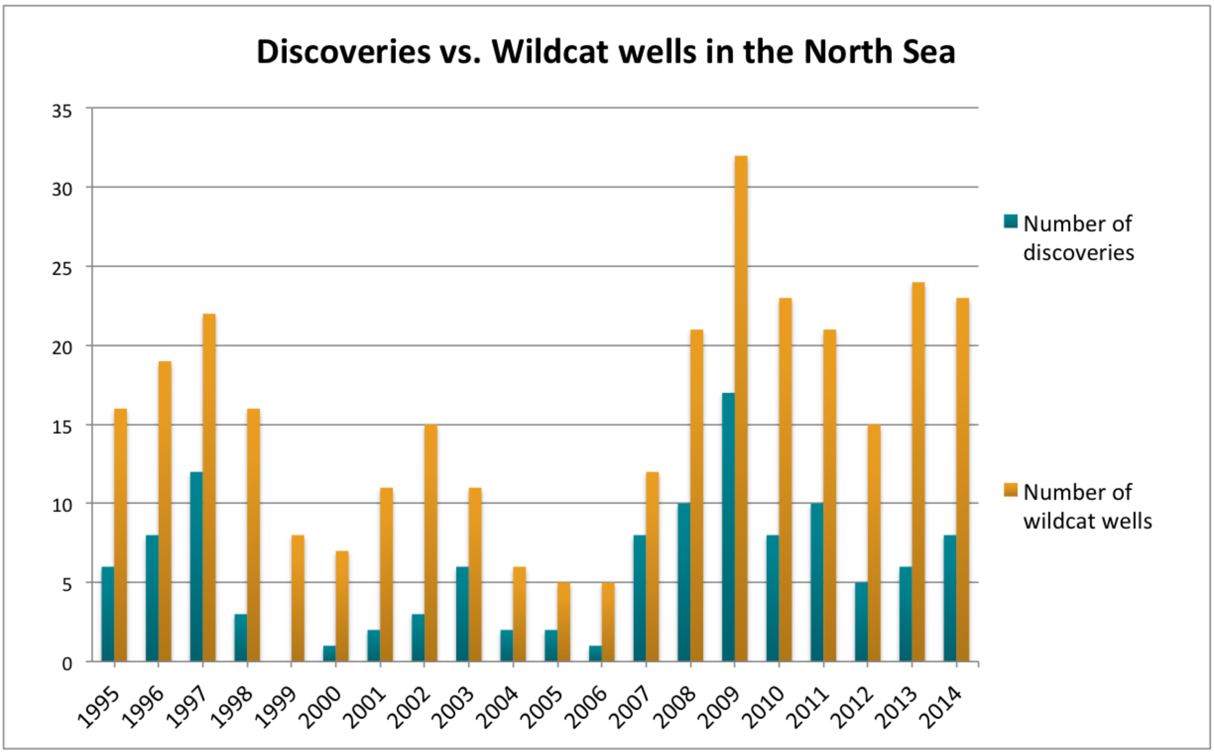


Figure 9 Discoveries vs. Wildcat wells drilled in the North Sea (NPD 2015B)

the exception of Johan Sverdrup in 2010), but also that the data reveal that there was many small discoveries in this period (NPD 2015B).

Figure 9 shows the number of wildcat wells drilled, and the number of discoveries made for each year in this period. As we can see from investigating this chart, there is a clear relationship between the number of wildcat wells that are drilled and the discoveries they produce, and from Figure A5 in the appendix we can see that these variables correlate strongly, with an R^2 of 0.63 for the entire period. This means that when a wildcat well is drilled, a discovery will happen 63% of the time. If each wildcat well that was drilled were successful in discovering hydrocarbons, this relationship would be absolute giving an R^2 of 1.0. As exploration activity is risky business, the probability of making a discovery increases with the number of wildcat wells that are drilled, especially if the prospects are less than optimal, but it is not guaranteed that it will happen. Compared with earlier years, we also observe that there is low drilling activity in the period 1999 – 2007, and especially from 2004 through 2007.

As we can see from the licensing in this period, the numbers of licenses awarded in the previous years were few, but they picked up again in the late 1990s. The reader will recall that the APA-system’s forerunner was first introduced in 1999 under the name ‘the North Sea awards', and as we can see in Figure 9, the drilling activity increased slightly after its introduction. We also see that the drilling activity really took off in the years following 2006, three years after the introduction of the APA-system. Although a bit lagged, by comparing Figures 8 and 9, we can observe that there seems to be a correlation between the number of licenses awarded and the number of wildcat wells drilled.

In 2010 we see a significant and unexpected increase in the curve, namely the Johan Sverdrup discovery. This discovery stands out, as it was discovered in the well-explored central part of the province, and was made in approximately 115 meters of water. The area containing the Johan Sverdrup field has been explored several times since the mid-1960s, and earlier exploration missed the deposit only by a few meters (Norwegian Petroleum 2015C). This shows that exploration technology and the IOCs competence in understanding the geology of the prospect might not always be sufficient, causing such outliers. In future research it will be advantageous to be able to control for such outliers, especially if there are more of them than in this particular analysis. *How* to control for this will be a task for future research.

In summary, we observe that the creaming curve for the North Sea province has not followed an optimal development intensity curve, and that the location and water depths of the discoveries are more or less random from 1973 and onwards. This tells us that the climatic challenges for the North Sea was overcome already by 1973, and that there seems to have been no significant challenges related to water depths in the province. We also observe that there seems to be a strong correlation between the number of wildcat wells drilled and the number of discoveries made, and that there is also a lagged relationship between wells and licenses, which conform to our expectations.

At the beginning of this analysis I mentioned that the curve followed a staircase like pattern, with each step looking like a creaming curve in its own right and that this could be due to the IOCs decisions to explore areas adjacent to the initial large discovery, or strong restrictions on exploration activity being limited to small areas. As we can see from the analysis, this is not the case, since many of the discoveries after every large increase have been found in parts of the province not adjacent to the initial large discovery. We also observe that the largest discoveries were all found in the northern areas of the province (abstracting from the Ekofisk field discovered south in the province in the learning period).

4.4 The Norwegian Sea province

The areas north of the 62nd parallel were first opened for exploration and development in 1980. As mentioned earlier, the reason for this delay was to ensure that the proper technology had been developed to safely pursue prospects in the increasingly tougher climate and water depths in the Norwegian Sea and Barents Sea provinces. Below we find Figure 10 and Figure 11, respectively showing the Norwegian Sea creaming curve from 1980 until 2014, and the licenses awarded in the province. As there has been less activity and fewer and smaller discoveries in the Norwegian Sea, the values on the Y-axis becomes smaller, enabling me to discuss this creaming curve in more detail than the curve in the analysis of the North Sea. The reason for such detailed description is to discuss the locations and water depths of the discoveries, arguing that the sequence of discoveries have not been affected by technological or climatic effects.

At first glance at the creaming curve for the Norwegian Sea (Figure 10), we can see that neither this curve follows the 'optimal development intensity' curve, but rather a staircase like pattern similar to the North Sea creaming curve. The following analysis discusses each six-year period after the initial learning phase. The purpose behind this sectioning is only for practical reasons, as it follows the slope of the curve, allowing us to comment on each period of growth and subsequent stagnation.

4.4.1 1980 – 1984: The learning period

The Norwegian Sea has so far proved to contain a lot less resources than the North Sea province, in addition to being more challenging with regards to tougher climate and water depths. The North Sea province of Norway was the most oil rich of the three provinces. In the Norwegian Sea province gas constitutes 50% of the resource base, and in the Barents Sea 70% of proven reserves (the remaining percentages being oil).

To control for technical variables, the initial four-year period (1980 – 1984) of the creaming curve is regarded as a learning phase, and that the rises to the curve in this period are omitted from the actual analysis of government influence, on the grounds that the explorers learn about the geology of the province in the first couple of discoveries. This period will however be discussed to illuminate how a learning period was also necessary for the Norwegian Sea province.

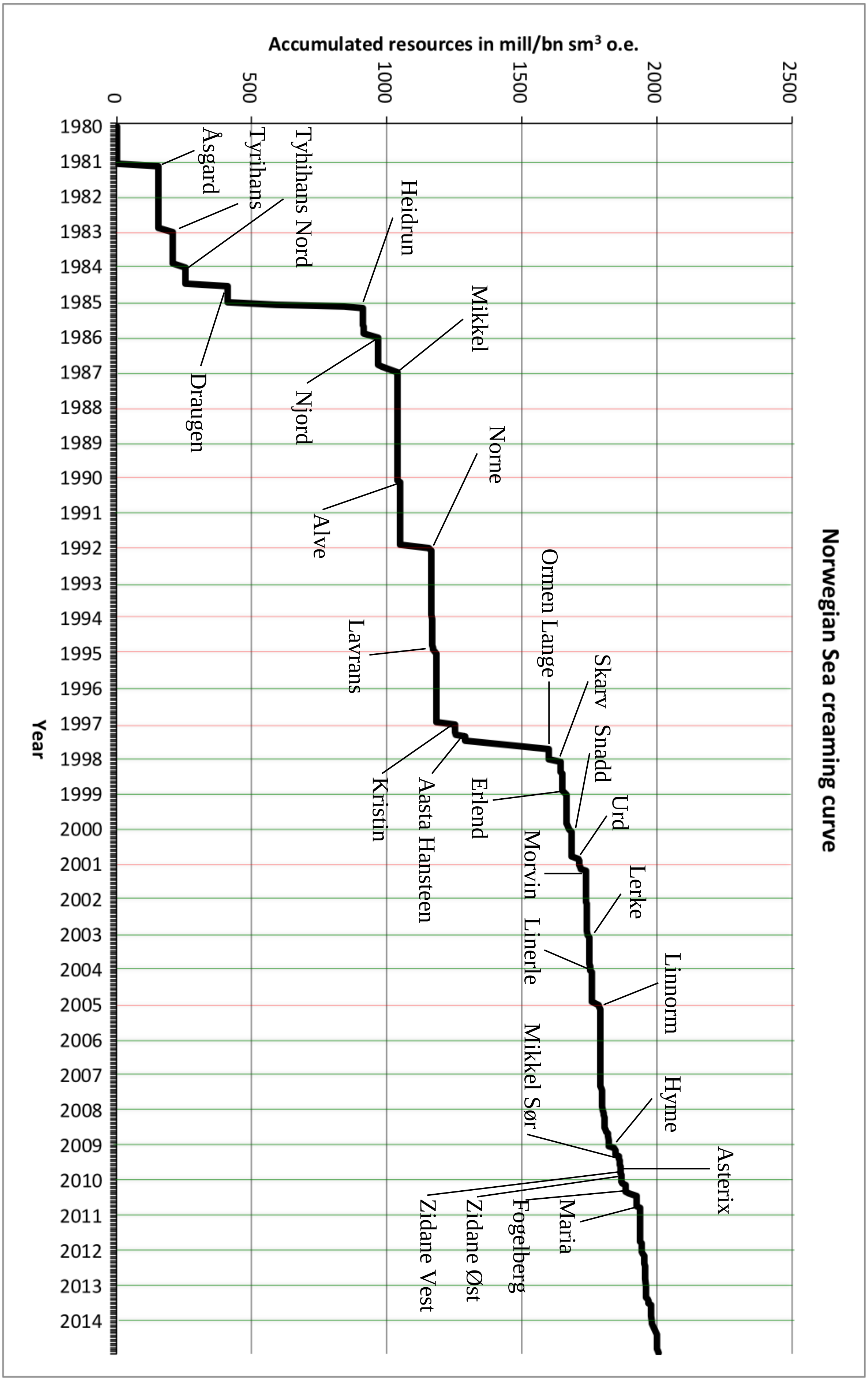


Figure 10 Norwegian Sea creaming curve (NPD 2015C)

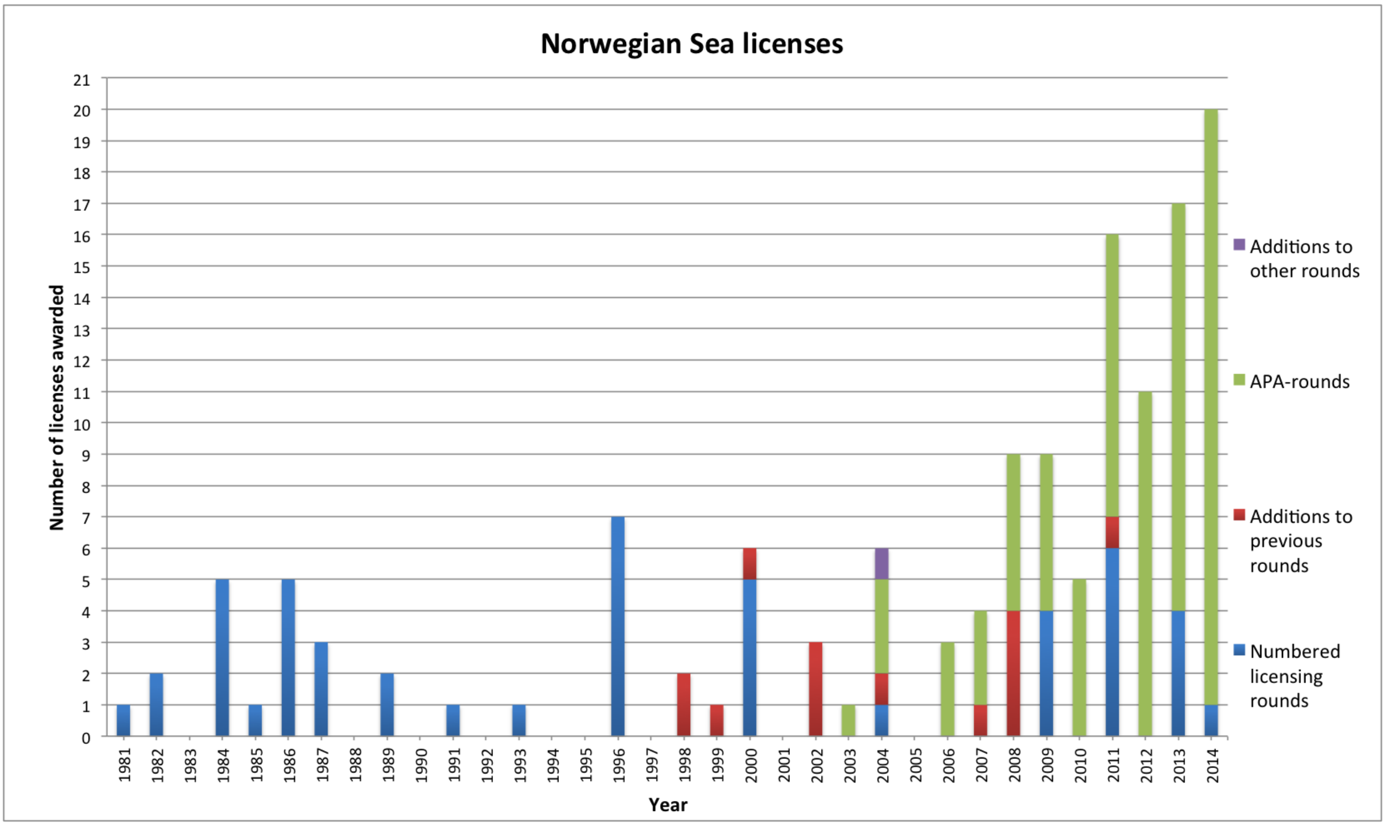


Figure 11 Licenses awarded in the Norwegian Sea (Norwegian Petroleum 2015B)

The first bump in the curve is the Åsgard field located on water depths of 240 – 300 meters centrally in the province, and was discovered in 1981. This field consists of the Midgard, Smørbukk, and Smørbukk Sør discoveries. Afterwards we see a small bump at the start of 1983, which is the Tyrihans field discovered 25 kilometers southeast of the Åsgard field. Tyrihans is found in about 270 meters of water depth. The increase in the creaming curve in 1984 is first the Tyrihans Nord (an extension of the Tyrihans field), and secondly the Draugen field that was discovered at a depth of about 250 meters further south in the central part of the province (Alveberg & Melberg 2013:71,101,108).

As we can see, these fields were discovered in water depths that vary between 250 and 300 meters. These depths are comparable to those of the North Sea, which means that the technology for exploring these prospects was not lagging at the outset of exploration activity. It is also assumed that by exploring centrally in the province this quickly, the technological challenges for operating in the harsh climates were also conquered early. As this was accomplished in such a short amount of time, it is reasonable to justify these initial four years as a learning period, despite it being shorter than the learning period of the North Sea[15]. We also see from Map A2 that the discoveries were primarily made in the same part of the

[15] Seeing that the main geological learning for the NCS is regarded as having been completed by 1973.

province, but with considerable distance between them. This means that these discoveries were not made by exploring the same play, but a result of separate exploration efforts. Thus, the IOCs were not limited to a certain area due to technological challenges.

4.4.2 1985 – 1990

As the learning period comes to an end, we observe the third largest (Draugen) and single largest (Heidrun) discoveries in the Norwegian Sea in 1985. Although these are shown in order opposite to what we would expect from theory, it is not too far off. As multiple licensees/license groups operate within the same province at the same time, the order of these discoveries becomes a product of one licensee making the discovery first. What is not in accordance with theory is that it is the *third* and not *second* largest (Ormen Lange) discovery that is found. The Draugen discovery was made centrally in the province in water depths of 250 meters, and the Heidrun field is also located centrally in the province, in about 350 meters of water depth (Alveberg & Melberg 2013:71,79).

According to theory, it would now be expected that the next discovery would be the second largest in the province. However, we see two small discoveries in the two subsequent years, and the second largest discovery does not appear before 1997. The discoveries in 1986 and 1987 are respectively the Njord and Mikkel fields. The Njord field was discovered in a water depth of 330 meters centrally in the province, 30 kilometers west of the Draugen field. The Mikkel field was also discovered centrally in the province, 30 kilometers north of the Draugen field at 220 meters of water depth. As we can see, these two fields were also discovered on water depths similar to those found in the North Sea (Alveberg & Melberg 2013:83,85).

After the Mikkel discovery in 1987 we see that the creaming curve flattens completely until 1990 when the Alve field is discovered in 370 meters of water depth in the northern areas of the Norwegian Sea. The Alve field was a very small discovery compared with the previous discoveries in the Norwegian Sea, and the deposit is currently under production from the Norne FPSO vessel. The flatness of the curve resumes again after the Alve discovery, and remains so until the Norne discovery in 1992.

To further investigate if this stagnation could have been caused by economical or technical variables, I have included another histogram showing the number of wildcat wells drilled and the discoveries made. The histogram covers an extended period to compare the years previous

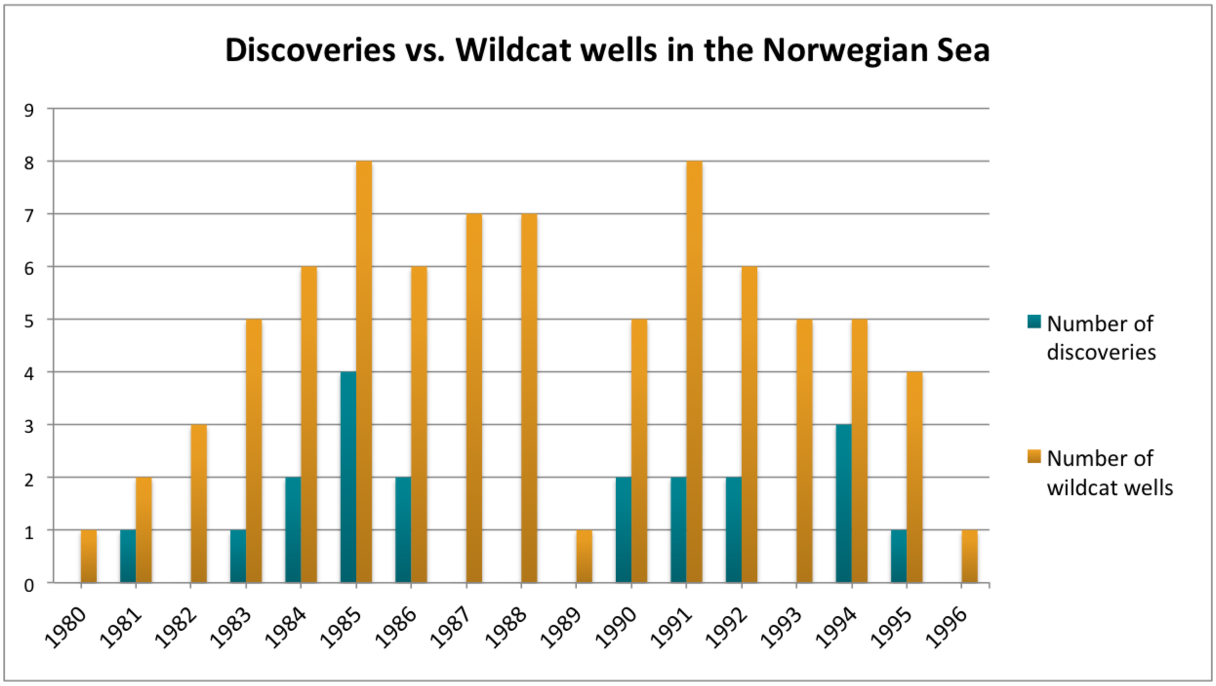


Figure 12 Discoveries vs. Wildcat wells drilled in the Norwegian Sea (NPD 2015C)

to and following this drought in discoveries[16]. As we can see, the number of wildcat wells that were drilled between 1987 and 1990 were among the highest in the selected period (with the exception of 1989), and the number of licenses awarded in previous years is higher in the previous, but declines heavily towards 1996 (as seen in Figure 11).

This means that neither oil prices nor a lack of drilling activity could have affected the slope of the curve in this period. We can also observe for this period that the discovered deposits were not located adjacent to each other, meaning that they were not discovered exploring the same play or prospect, further indicating that the licensing policy was not strongly restricted to a single area, but spread out over the province. This stagnation is directly caused by government influence, which I will come back to in the following chapter.

4.4.3 1991 – 1996

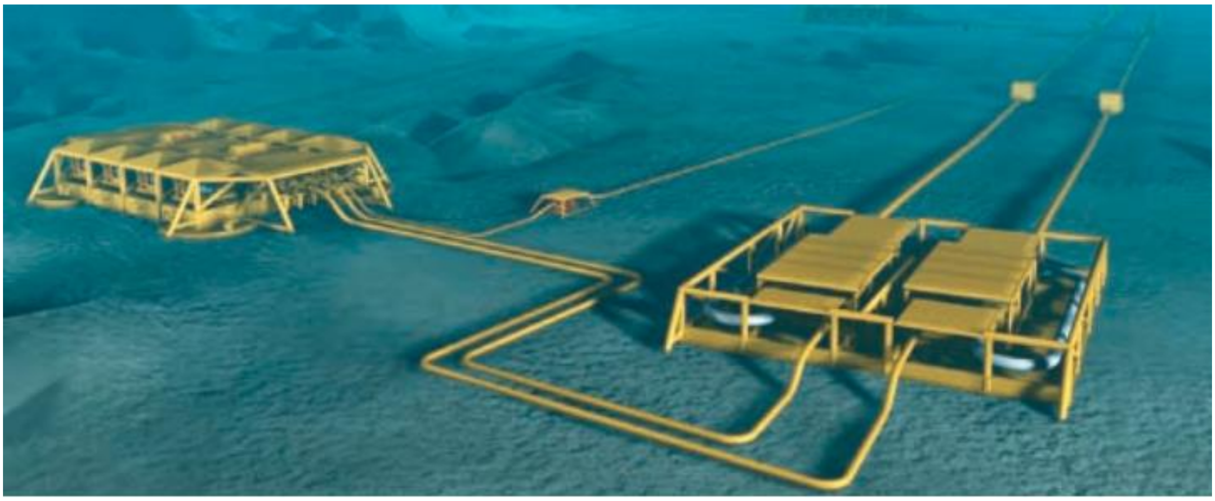
In this period there are only two mentionable discoveries, the first being the Norne field discovered in 1992. The Norne field is located approximately 80 kilometers north of the Heidrun field in the northernmost part of the province, and the water is about 380 meters deep in the area. The field is being developed by subsea templates installed on the seabed. The second increase in 1995 is the Lavrans discovery, which is listed as likely to be developed but that this is not yet clarified. This field is located on about 280 meters of water depth centrally in the province (Alveberg & Melberg 2013:85; NPD 2015A; NPD 2014B).

[16] We can also see that this chart registers more discoveries than I have discussed for some of the years. These discoveries are so small that they are very difficult to observe in the creaming curve, and are likely to have fallen within the NPD's "resource category 6".

We observe that the curve once again peters out until new discoveries once again are made in 1997. As we can see from Figure 12, the number of wildcat wells drilled declined steadily from 1991, but discoveries were however made both in 1994 and 1995 (despite most likely not being commercially viable). We also observe in Map A2 that the discoveries in this period were made independently from each other, and from pervious discoveries (i.e. not adjacent).

4.4.4 1997 – 2002

In this period we see a lot more discoveries appearing in the creaming curve than in the past two periods. In 1997 we first see the Kristin discovery, secondly the Aasta Hansteen, and thirdly and third the Ormen Lange discovery. The Kristin field is a gas condensate field located centrally in the Norwegian Sea province, on water depths of about 370 meters. Aasta Hansteen is located in 1270 meters of water depth discovery far north in the province and is under planning by the licensees. The development of the field is dependent on new solutions for gas transportation from the Norwegian Sea (Alveberg & Melberg 2013:82,123; NPD 2014B).

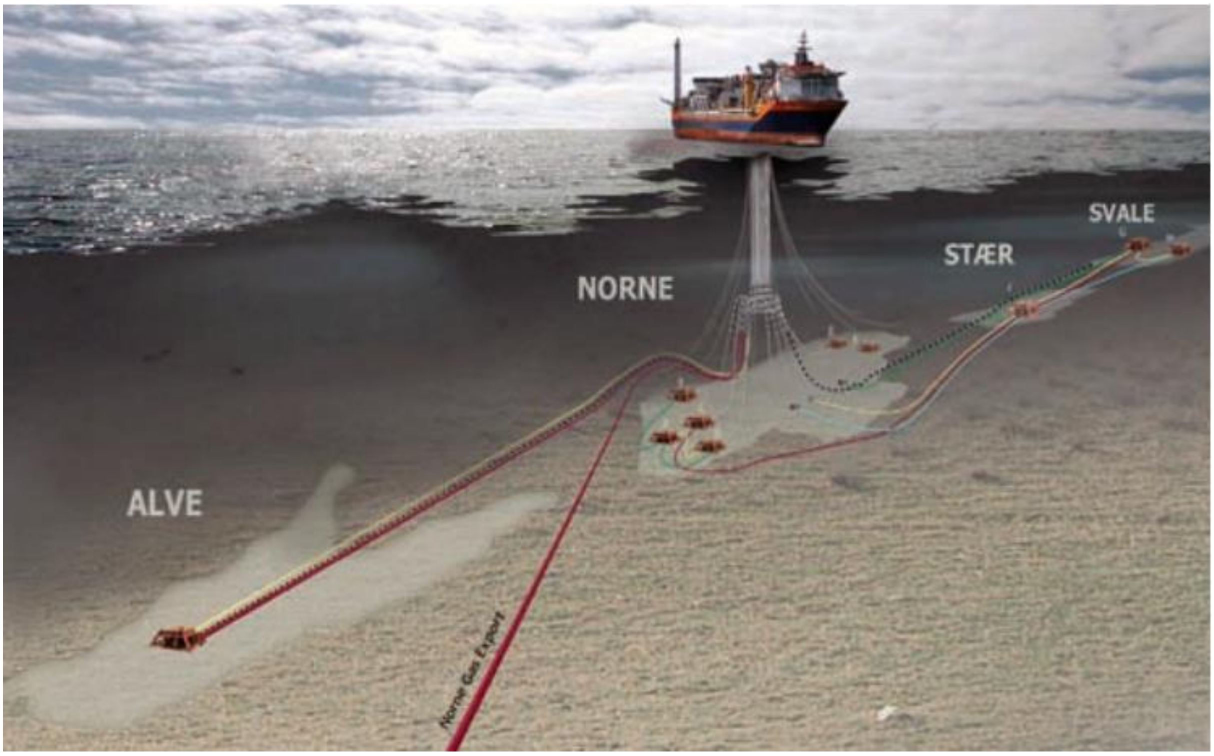


Pictured: The Ormen Lange subsea template (Alveberg & Melberg 2013:86)

The Ormen Lange field is located in the southern part of the province, in water depths varying from 800-1100 meters. Because of these immense water depths and challenging seabed conditions, new technology had to be developed to put the field into production. As the field was discovered without this technology (exploration activity is not reliant on establishing infrastructure on the seabed), it is not regarded to be a problem for the analysis (Alveberg & Melberg 2013:86). As theory would have it, we can see that the curve starts to peter out after the Ormen Lange discovery, and the following years exhibit small but numerous discoveries.

In 1998 we see another increase in the curve. This is the Skarv field, which is located in the northern part of the province, and the water depth in the area varies between 350 and 450 meters. This field is also being developed by subsea templates, and is being managed by a FPSO, which is tied to five other subsea templates as well. The next increase is assumed to be the Erlend discovery in 1999 located close to the Kristin field. The discovery is still in the planning phase, will be developed with subsea templates, and is expected to be tied to the Kristin infrastructure (Alveberg & Melberg 2013:89,125).

The first observable increase in 2000 is not thought to be the Snadd discovery, which has been included in the Skarv field by the NPD. The second increase is the Urd field, which is located north east of the Norne field in the northern part of the Norwegian Sea province, and the water depths in the area is about 380 meters. This field is developed by subsea templates along with the adjacent Norne field, and the well stream is processed by the Norne FPSO (Alveberg & Melberg 2013:102; NPD 2015A).



Pictured: The Norne FPSO and subsea templates developing surrounding fields (Alveberg & Melberg 2013:68)

The last discovery in this period is in 2001, where we can observe yet another small increase to the curve, namely the Morvin field. This field is located centrally in the province at water depths of about 350 meters. The field is developed with two subsea templates that are tied back to the Åsgard B platform (Alveberg & Melberg 2013:84). As we can see, the discoveries made in this period were located at water depths below 320 meters, independent and far apart from each other in the province.

4.4.5 2003 – 2008

The two observable discoveries in 2003 and 2004 are respectively the Lerke and Linerle discoveries, while the increase in 2005 is the Linnorm discovery. The Lerke deposit (on a water depth of 377 meters) has been included in the Urd field and the Linerle deposit (on a water depth of 342 meters) is listed as included in a different discovery without stating explicitly which one. The discoveries are adjacent so it is possible that they are both included in the Urd field. The deposits located in the northernmost part of the province. Linnorm discovery was made 20 kilometers west of the Njord field centrally in the province, on about 310 meters of water depth. The field consists of gas and condensate, and the licensees are evaluating the future of the project (Alveberg & Melberg 2013:125; NPD 2015A; NPD 2014B).

The first field listed as developed in this period is the Yttergryta field, discovered in 2007. The Yttergryta field is located centrally in the province on water depths of about 300 meters. The deposit was developed with subsea templates and tied to the Midgard deposit in the Åsgard field (Alveberg & Melberg 2013:108). The two discoveries we can observe in 2008 is the Skuld field, consisting of the Dompap and Fossekall discoveries, located in the northernmost part of the province, respectively 16 and 26 kilometers north of the Norne FPSO vessel, to which they are tied and developed by subsea templates (Alveberg & Melberg 2013:117). We observe for this period that the discoveries have in some cases been made in areas adjacent to earlier discoveries, and others in areas without other discoveries.

4.4.6 2009 – 2014

In 2009 and 2010 we get a small, but unexpected, upsurge in the curve. The listed developed discovery in 2009 is the Hyme field, located just west of the Draugen field and 19 kilometers northeast of the Njord field in the central part of the province. The water depth in the area is about 260 meters, and the field is developed with a standard subsea template that is tied to the Njord facility. The second discovery is thought to be the Mikkel Sør discovery (also located centrally in the province), which was in the planning stage in 2013. The field will most likely be developed with subsea templates tied to the Mikkel infrastructure. The third increase to the curve this year is thought to be the Asterix discovery, located under more than 1,335 meters of water, far northwest in the province. The discovery is expected to be developed with subsea templates tied to the Aasta Hansteen discovery (Alveberg & Melberg 2013:115,125).

Although hard to identify in the curve, the discoveries in 2010 are the Maria, Fogelberg, and the Zidane East and Zidane West discoveries. The Maria discovery is about 20 kilometers southeast of the Åsgard complex, located on 303 meters of water depth. The discovery is still in the planning phase, and the development plan is expected to be complete by 2016. The Fogelberg discovery is located about 10 kilometers north of the Smørbukk deposit, and the water depth in the area is 280 meters. The deposit will be developed with subsea templates tied to existing infrastructure nearby. The Zidane fields were discovered 15 kilometers northwest of the Heidrun field on 344 meters of water depth. The likely development is subsea templates that will be tied to the Heidrun platform. In 2011 we can see one increase in the curve, which is the Alve Nord discovery. This field is located only eight kilometers west of the Norne field, in 369 meters of water depth. The development of the discovery is dependent on being tied to existing fields in the area. All these discoveries were made in the central and north-central parts of the province (Alveberg & Melberg 2013:125; NPD 2014B).

To summarize, the creaming curve for the Norwegian Sea province does not follow an optimal trajectory, and is comparable to the North Sea creaming curve by following a staircase like shape, only with fewer steps. We observe that these steps are not caused by exploration activity being limited to a certain area within the province, but that the discoveries are made all across the province each period. We also observe that there are two very flat sections in the curve. As we can see by the discoveries made in these periods, they seem to have been discovered at mostly in the central part of the province, but that there is considerable distance between them. We also observe that the water depths at which the discoveries have been made in also vary greatly. From this (and the IOCs technological capabilities discussed in section 3.2.1), we can be fairly certain that the technology for exploring the province was not lagging, and that the sequence of discoveries has not been decided by technical factors.

4.5 The Barents Sea province

As stated earlier, the hydrocarbon deposits in the Barents Sea consist mostly of gas, making it very difficult to economically justify the development of many of these fields. In the Barents Sea creaming curve we observe that the scale on the Y-axis is smaller than both other provinces, meaning that the discoveries that are observable in this curve might not have been in either of the others. Because of this, the curve looks bigger and it is easier to discuss the curve in more detail than if these values were the same as for the North Sea. The differences between the curves become evident in Figure 16 presented in the following chapter, which will be used to compare the provinces. Upon investigating the discoveries in the province it is clear that most of these will not be developed unless the economy or infrastructure plans changes. This leaves them in the ominous “resource category 6”. As the Barents Sea is mostly endowed with gas occurrences (70%), developments of such discoveries are dependent on being tied to other fields for commerciality. This is necessary because of the lack of existing infrastructure and the long distance to the European gas market. Nevertheless, as exploration activity is the object of examination, the development decisions will not be too important.

Below are Figures 13 and 14, respectively showing the Barents Sea creaming curve and the number of licenses issued for the province each year. As we first look at the Barents Sea creaming curve, we clearly see an inverse S-shape to the curve, thus observing that is does not follow the optimal development intensity curve. We also observe a long period of stagnation in the middle of this curve. Next, I inspect the curve in more detail, in periods of varying length. The spans of these periods are based on the curve’s shape, selecting them as best suited for our purposes.

4.5.1 1980 – 1984

The Barents Sea province is very special with regards to operational climates for exploration and development activity. We assume that there has been a learning period in this province as well, but that this period has spanned far longer than in the other provinces. The reason for this is that the petroleum systems applied to interpret seismic data in the province has been analogous to those of the North and Norwegian Seas. This has led to wrong interpretations of the geology, and an underestimation of the resource potential of the region. Geological learning from the Goliat and Nucula discoveries has shed new light on what kinds of petroleum resources have been generated in the province (Carstens 2009). Therefore, the learning period of this province is regarded to have lasted up until the early 2010s, but that it is difficult to estimate an exact point where it ended, as it is still too soon to tell.

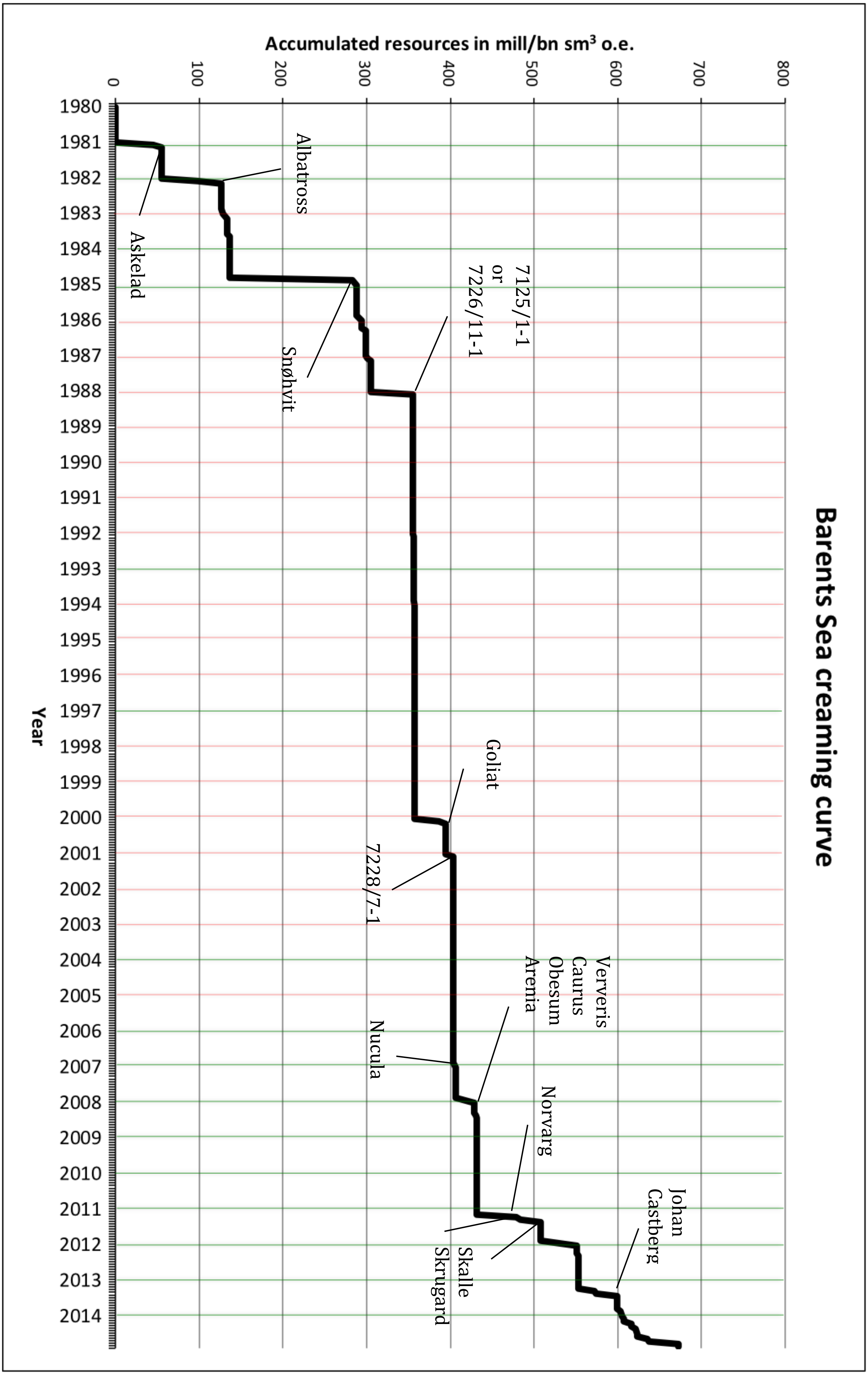


Figure 13 Barents Sea creaming curve (NPD 2015D)

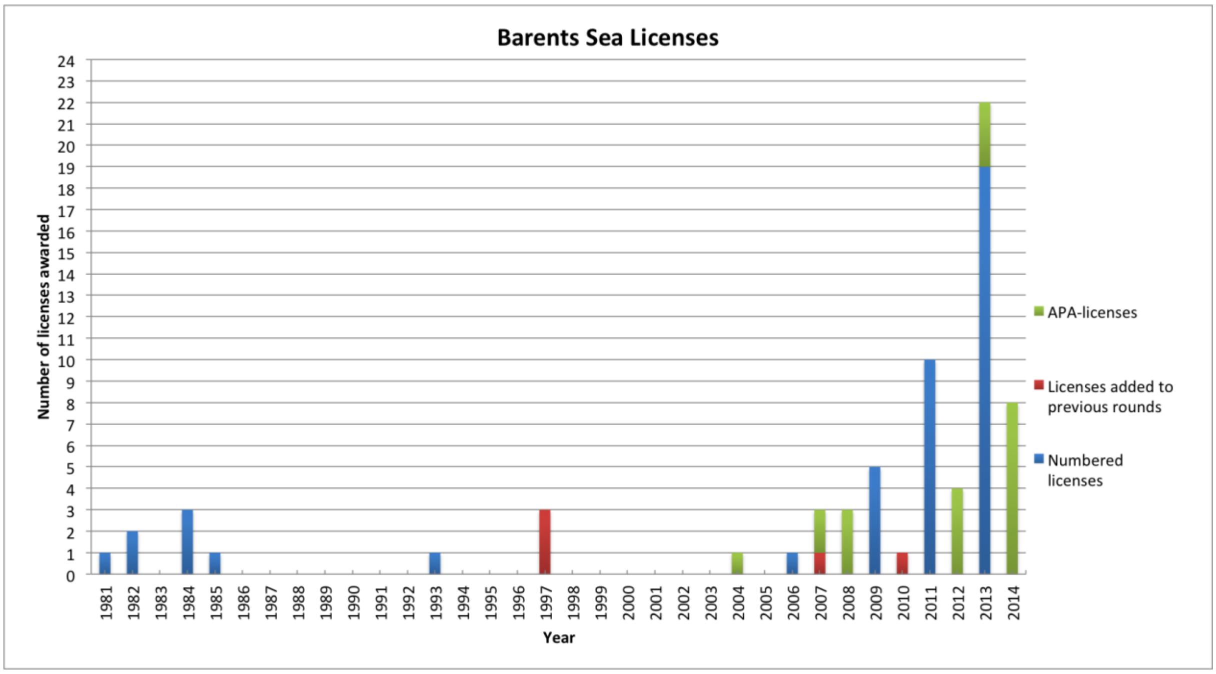


Figure 14 Licenses awarded in the Barents Sea (Norwegian Petroleum 2015B)

Regarding the technological challenges, except for the seismic technology lag, the water depths in the Barents Sea are on average the same as in the Norwegian Sea, but generally more challenging than in the North Sea. I argue that the technology for exploring these depths were in place by the opening of the areas north of the 62nd parallel in 1980 (ref. section 3.2.1). It is however assumed that the severely challenging arctic conditions of the Barents Sea have presented technological challenges that needed to be overcome, but that these were overcome by the time the first wildcat well was drilled.

By examining the curve, we clearly observe three discoveries in the start of the curve (before 1985). These are the Askeladd, Albatross and Snøhvit deposits that are all adjacent to each other and included in the Snøhvit complex (as marked in Map A3). The deposits were discovered in water depths ranging between 310 and 340 meters. The Askeladd and Albatross deposits were discovered in 1981 and 1982 respectively, and lie in the southern part of the province (Alveberg & Melberg 2013:93; NPD 2015A; NPD 2014B). By this we can assume that the beginning slope of this curve is mostly caused by the discovery of adjacent fields.

4.5.2 1985 – 1988

In 1985 we can see that the curve starts to peter out, exhibiting a few small discoveries before a larger increase in 1988. Although hard to identify, one of the two discoveries in 1987 is the Tornerose deposit, while the other is not mentioned on the NPD's FactPages. Tornerose is located at 400 meters of water depth east of Snøhvit, and the development plans involve tying the development of the deposit to the Snøhvit complex. The larger increase in 1988 is either the 7125/1-1 discovery, or the 7226/11-1 discovery. It is hard to tell these apart as the data reveal only one discovery and the size of the two aforementioned discoveries are not provided by the NPD (NPD 2015A; NPD 2015D). Both were discovered in water depths under 250 meters and are listed as not very likely to be developed, and are thus categorized as "category 6" resources (Alveberg & Melberg 2013:126; NPD 2015A). These resources were also discovered quite far east in the central and south-central parts of the province. After these discoveries, the curve flattens out completely.

4.5.3 1989 – 1999

After the discovery in 1988 we observe a very long period of stagnation. The drought in discoveries lasted for a whole decade until the year 2000[17], when the Goliat field was discovered. To further investigate this drought, another histogram (Figure 15) has been included, showing the number of discoveries and wildcat wells that were drilled in the period from 1998 until 2000. As we can see, discounting the 1992 observation, there is a downward trend in drilling activity in the province from 1988 until 2000, with no wells drilled in the years 1995 through 1999. We can also observe that there are no discoveries other than those mentioned above, which resulted in no development. This helps explain why the curve is almost completely flat in these years. However, we will see in the nest chapter that the policy

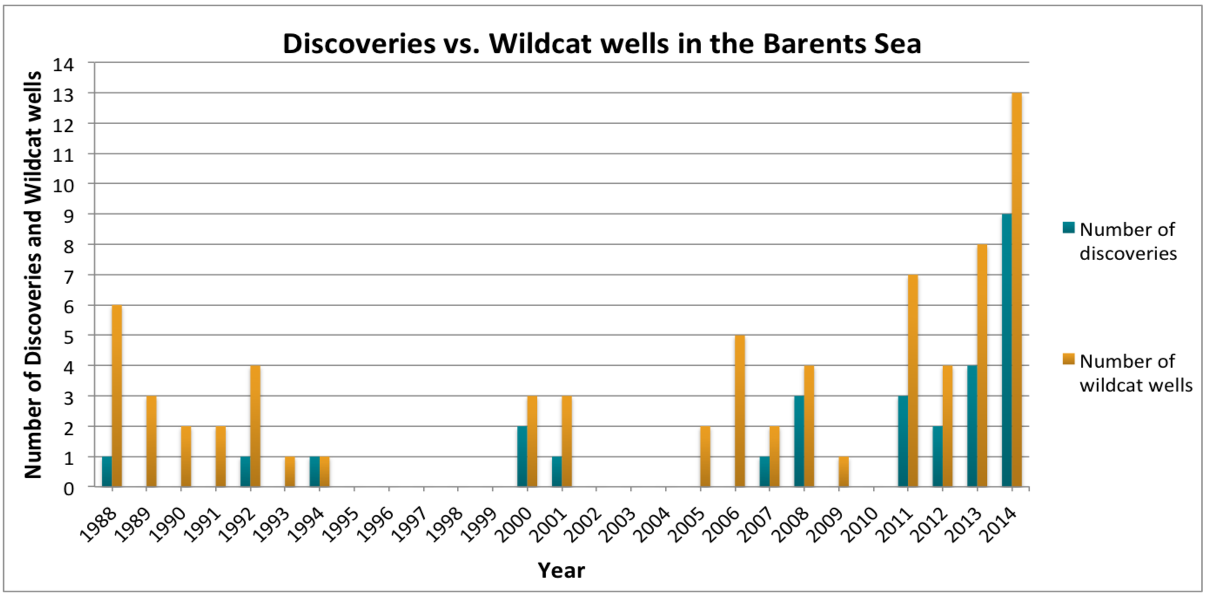


Figure 15 Discoveries vs. Wildcat wells drilled in the Barents Sea (NPD 2015D)

[17] I will point out that there was made two discoveries in this period, but that these were miniscule. The discoveries were made north and east in the province respectively, far away from any other discoveries, in water depths of 450 and 370 meters.

choices followed by the Norwegian government in this period also had a direct effect on the slope of this curve.

Since the Barents Sea province is mostly endowed with gas, there is little existing infrastructure, and that the arctic conditions present severe and constant challenge to operations (especially during the long winter), the break-even price for exploring and developing resources in this province becomes naturally much higher than the others. In the period 1988-1996, we can see from Figure A7 in the appendix that the price of Brent crude remains quite stabile around USD 18 per barrel, with the exception for a spike in 1990 to USD 36 per barrel. This spike could be the reason we see a spike in drilling activity in 1992. Albeit the effects being small, Mohn & Osmundsen (2006) have found that there have been long-term effects of price elasticity on Norway.

The price drops a little in 1999, before it again increases by the end of 2000. We do observe a decrease in the price again in 2002 to a pre-1998 level of about USD 18 per barrel. As we see in Figure 15, drilling activity resumed in 2000 and 2001 as the prices increased to USD 25 per barrel, and then stopped as the price declined (NPD 2015D; EIA 2015). This variation in drilling activity can be due to the perceived break-even prices for operating within the region, making exploration attractive in times of high prices, vice versa.

4.5.4 2000 – 2010

The dry spell in discoveries ends in 2000 when the Goliat field is discovered. The field is located 50 kilometers southeast of the Snøhvit field in water depths ranging between 360 and 420 meters, and is developed by a circular FPSO and eight subsea templates (Alveberg & Melberg 2013:114). In 2001 we observe another small increase in the curve, discovery 7228/7-1, which is located east in the province at water depths of 288 meters and is listed as a “category 6” resource (NPD 2015A; NPD 2014B).

As we observe in Figure 15, no wells were drilled from 2002 through 2004, explaining the flatness of the curve in these years. Drilling resumed again in 2005 producing a few discoveries in 2007 and 2008. These are the Nucula (2007), Arenaria, Obesum, Caurus, and Ververis (2008) discoveries which all are listed by the NPD as not very likely to be developed (NPD 2015A). These discoveries are scattered centrally in the province.

4.5.5 2011 – 2014

Even if the Barents Sea has seen exploration activity for over thirty years, it is still a very immature province. As we can see from the creaming curve, 2011 marks a new period of resource growth in the province with the discovery of several new deposits. This year we get the Skrugard, and Skalle discoveries. These discoveries are located in about 370 meters of water depth. As we can see from Figure 15 there were three discoveries this year, but by looking at the curve we only observe two. Due to the small size of the Skalle discovery compared to the two others, it is thought to not be observable in the curve. All fields are currently under planning, with the exception of the Skalle deposit, which is under evaluation.

The first Johan Castberg discovery was made in 2012, but as we shall see in the next paragraph, two more discoveries have later been included in the discovery (Alveberg & Melberg 2013:126; NPD 2015A; NPD 2014B). In 2012 we see two more increases in the curve: the Salina and Havis discoveries. Salina is located just north of the Gotha discovery, in 340 meters of water depth. The discovery is listed as not likely to be developed (NPD 2015A; NPD 2014B). The Skrugard and Havis discoveries are adjacent to, and have later been included in the Johan Castberg discovery. However, they appear as three separate discoveries in the creaming curve. In 2013 we get the Gotha, Wisting, Nunatak, and Skavl discoveries. Of these, only Gotha has been deemed likely to be developed, while Skavl and Nunatak are listed as not likely to be developed. Wisting has not yet been evaluated. These discoveries were made in water depths ranging from about 340 to 400 meters. The last discoveries we see in 2014 are Kramsnø and Drivis, whereas Kramsnø is listed as not likely to be developed and Drivis is under planning. The discoveries were made at water depths of 403 and 345 meters, respectively (NPD 2015A).

Analyzing the development intensity in the Barents Sea is very difficult. This is because of the special circumstances of the province with regards to climate, technology lag, low petroleum potential, few discoveries, and few wildcat wells drilled. This makes it difficult to analyze the curve for evidence of government influence by itself. We can see that discoveries have been made both adjacent to other fields, but also scattered across the province.

To summarize this chapter, we observed that the Norwegian Sea and Barents Sea curves have completely flat stages of the curve, while the North Sea curve shows a higher continuity in the discovery rate. The main reason for this, as I will show in the following chapter, is the policy choices followed by the Norwegian government for these periods. Since petroleum operations started in the Barents Sea, 99 wildcat wells have been drilled, compared to 218 in the Norwegian Sea and 674 in the North Sea (528 since 1980) (NPD 2015B, 2015C, 2015D). The Barents Sea is a very special province due to the arctic climate and fragile environment, as well as close proximity to the former Soviet Union and today's Russia. I will also discuss the special circumstances of the Barents Sea in the following chapter.

As stated repeatedly in this chapter, it seems that there is no direct link between the shape of the curve and location of the discoveries. One would expect that the curve would deviate if IOCs were only able to explore one part of the province at the time, but the discoveries seem to have been made at random locations all across the provinces. This means that there have not been severe technical challenges inhibiting the IOCs from exploring the provinces after each learning phase. We also observe that most of the discoveries in the latter stages of the curves are made in well-explored parts of the province.

Also, we clearly observe that the creaming curves for all provinces are flatter than what the expected 'optimal development intensity' would be. Seeing that the major discoveries in each province have been delayed far longer than technical or other variables would suggest (considering that most discoveries seem to have been made at random locations and water depths in each province), I argue that the deviation between the 'observed' and 'optimal' development intensities must be caused by political factors. I further argue that these deviations are of a moderate degree, since they would have to be spaced further apart, or closer to the end of the curves for me to argue a level of lower development intensity.

In the following chapter I will show how political determinants and government influence are the cause of these deviations, by presenting the political policies that directly affected the booking rate in the Norwegian provinces.

5.0 The effects of government influence

In this chapter, I will discuss how the deviations between the 'optimal' and 'observed' development intensities in the petroleum provinces on the NCS were affected by government influence. I start off by looking at alternative explanations to the deviations, and with these exhausted, government influence should stand as a valid explanation for the deviations. Secondly, I will examine the effects of policies on the North Sea, the Norwegian Sea, and the Barents Sea provinces, measuring the degree of deviation based on the scale established in section 2.6. This section will show that the policy choices taken by the Norwegian government has had clear effects on the development intensity for all provinces. Therefore, this section relies much on the historical empirics presented in Al-Kasim (2006), but the focus is on the utility of using the creaming curves as an indicator for measuring the government influence on development intensity.

As we observed in the previous chapter, the 'observed development intensity' presented by the creaming curves clearly deviates from the counterfactual 'optimal development intensity'. To remind the reader, the assumed optimal booking rate of discoveries is the one where the largest discoveries are found first, and where the size of discoveries successively diminishes over time. Inferring from the previous chapter, there is no clear relationship between the location and timing of the discoveries for any of the cases. Thus, the expected 'observed development intensity' *without* government influence should, ceteris paribus, look much like that of the 'optimal development intensity'. As the shape of the curve is mostly affected by the order of the largest discoveries, these are the ones that will be emphasized in this chapter. These discoveries are marked in Figure 16.

Could the deviations we have observed be caused by explanations other than government influence? If exploration activity has been restricted by technological variables (i.e. challenges related to climate and water depths), one would expect that this activity would be limited to certain areas and in turn expand gradually (i.e. from southern to northern climates, and from shallow to deep waters). The reader may have noted that contrary to this, the discoveries have been made randomly across each province. Map A4 shows which blocks have been awarded production licenses by 2014, illustrating the extent of exploration activity.

There seems to be a random pattern in the exploration activity across provinces, which shows that the climate really has not been a hindrance.

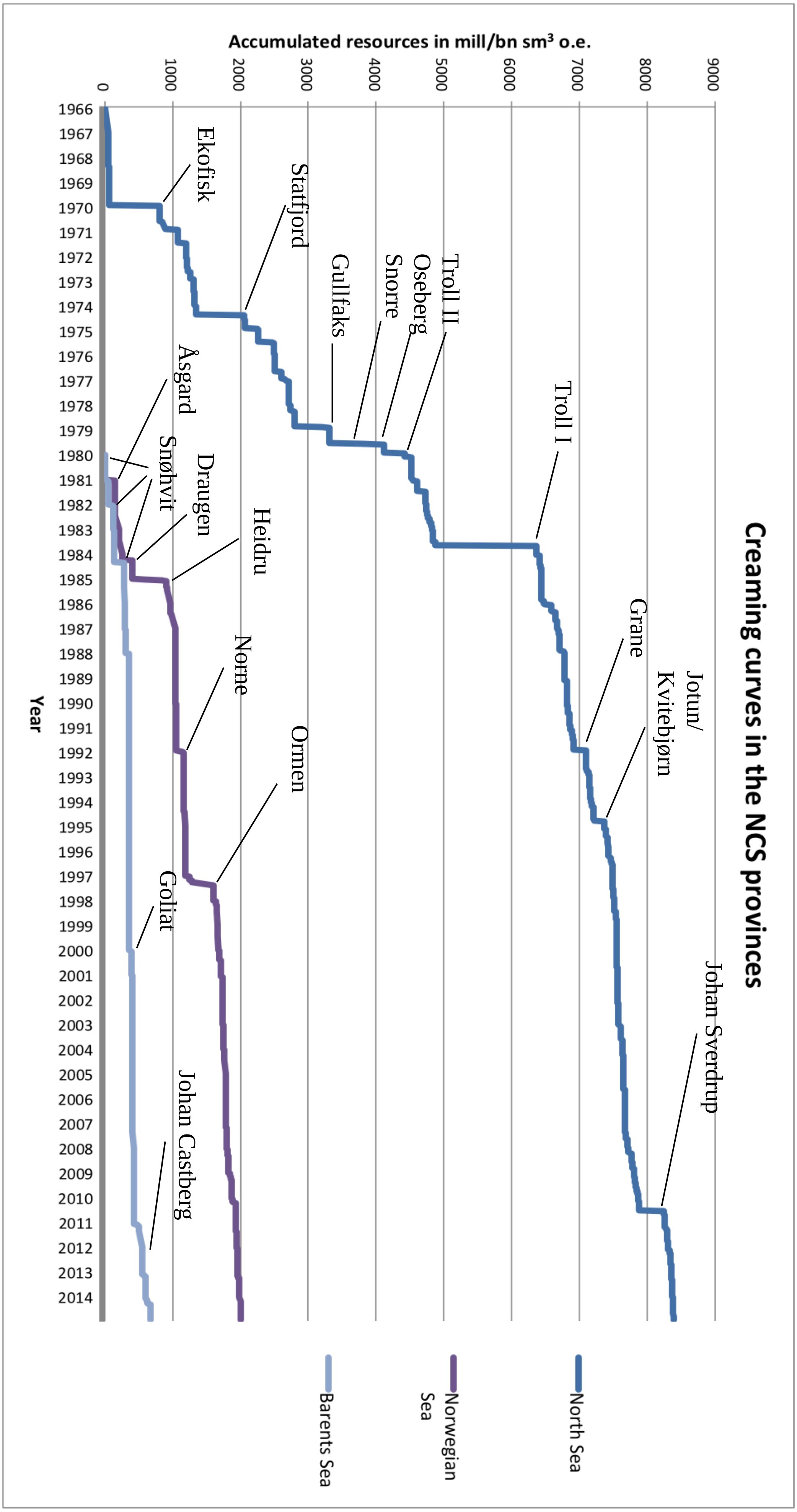


Figure 16 Creaming curves of the NCS compared (NPD 2015B, 2015C, 2015D)

Considering the IOCs capability to explore the deepest waters on the NCS by 1975 (ref. technological capabilities discussed in section 3.2.1), it is reasonable to assume that they were also capable of exploring the North Sea province to its full extent by the end of the learning phase in 1973. Seeing that this chapter focuses on the largest discoveries in each province, I assume that the rewards these discoveries were thought to bring outweighed their costs. As long as the technological challenges of drilling the prospects are overcome by the end of each learning phase, there seems to be no other factor than government influence keeping them from being discovered at earlier stages.

As stated in the theory chapter (section 2.4), information providing proper knowledge of the geology is very important for the exploring parties, before drilling activity ensues. If the exploring parties do not have this information, they cannot rank all prospects in the province. Discovering top prospects first is presupposed by access to proper information. As a result, a lack of sufficient information could manifest itself as deviations between the curves. In the Norwegian case, nearly all the data on the geology in the North Sea province had been gathered before the first licensing round in 1965, and in the Norwegian and Barents Seas before the opening of the 62nd parallel in 1980. This information was made available for purchase to the IOCs, giving the government an important base for assessing the value of different prospects (Al-Kasim 2006:203,26-27). Even though seismic technology (like all other technology) has advanced over the years, it was probably from the outset adequate for detecting the most obvious geological anomalies, enabling the IOCs to find the largest discoveries first. One important exception here is the seismic technology lag present in the Barents Sea province, which will be discussed in greater detail in section 5.3.

Also, earlier research has shown that price fluctuations have less effect on exploration cycles in regulated high-tax environments than in unregulated petroleum provinces, and that exploration activity on the NCS have evolved into an autonomous profit generating activity. Additionally exploration activities are not necessarily capital intensive, as all capital equipment is hired by the IOCs in the long term for these specific activities (Mohn & Osmundsen 2008:316,306-307). Therefore, oil price fluctuations should not hold much significant explanatory power over the deviation between the 'optimal' and 'observed' development intensities. The following sections discuss the policy choices taken by the Norwegian government and how these choices have directly affected the development intensity for each province.

5.1 The North Sea

After the initial liberal licensing policy followed by the Norwegian government to attract IOCs in the first learning phase on the NCS (as seen in Figures 8 and A6), the government soon introduced a more restrictive attitude towards licensing of new acreage. For the development intensity to follow an optimal path, it is necessary that the IOCs have free access to explore the most promising prospects first. However, having witnessed the devastating effects of the petroleum industry on the Dutch economy and society, the Norwegian government became very attentive not to fall in the same trap. Because of this, there was an astonishing consensus among Norwegian politicians to keep a prudent and gradual approach to petroleum operations. There was also political consensus that the only realistic way of regulating the development intensity was by regulating the speed, and reserve potential of block allocations to the IOCs (Al-Kasim 2006:36,38).

After the second licensing round had proven that giant oil fields on the NCS existed (through the Ekofisk discovery[18]), the government took a more restrictive attitude towards the licensing policy. The focus of the Norwegian government was now on keeping the development intensity from escalating before the government had developed its own petroleum administration and an understanding of the effects petroleum operations would have on Norwegian economy and society. This attitude lasted from the 1960s to the early 1980s (Al-Kasim 2006:84-85). As the rise in oil prices in the early 1970s resulted in rapid growth in the petroleum sector, the desired level of development intensity became a topic for political debate. As a result of this debate, the third licensing round was set to last from 1974 to 1977, awarding only 20 blocks with the main intention of securing any deposits along the UK border (Al-Kasim 2006:26). This alone shows that the Norwegian petroleum policy, at this stage, was aimed at keeping the development intensity low, in order to control the side effects of the industry. However, it was not kept at the lowest point because they could risk forfeiting resources to the British.

The Statfjord discovery is an example of the policy choice above. The Statfjord acreage was awarded in the extraordinary licensing round in 1973, and the Statfjord field was discovered a year later in 1974. As the Norwegian authorities lingered in allocating blocks further north, Shell and Esso expressed great interest in acquiring the acreage in 1972, as they discovered

[18] The Ekofisk discovery is probably the most important discovery of all, on the NCS, because it rejuvinated the search for North Sea oil after the industry had become pesimistic in the late 1960s (Vand den Bark & Thomas 1980).

the Brent field on the UK side of the border in 1971 (Al-Kasim 2006:28; Shell UK n.d.). They suspected that the Brent field stretched over to the Norwegian side of the border. However, Norwegian politicians waited a whole year before initiating an extraordinary licensing round. The allocation of the Statfjord acreage became an urgent matter, as the prospect was very close to the median-line between the UK and Norway. In fear that the Statfjord and Brent fields were connected, the Norwegian government issued this acreage rapidly to secure any petroleum that might be on the Norwegian side (Al-Kasim 2006:27-28).

It is extremely difficult to know in advance if adjacent discoveries are separate or connected without exploratory drilling of wildcat and appraisal wells. The Norwegian government had no choice but to allocate the blocks lest they would forfeit resources to the UK. By comparing the timing of the Brent and Statfjord discoveries, we clearly see that the Statfjord field could have been discovered much earlier, even though the learning period lasted until 1973. If the Statfjord field had been discovered in 1971 (as Brent was), the 'observed development intensity' would have followed a much more optimal path from the beginning.

That the learning period lasted so long is not necessarily a result of the IOCs lack of competence. Since they were able to discover the Brent field in the same area as the Statfjord discovery three years earlier, they would have overcome the essential challenge of drilling at this location. The fact that the Norwegian authorities still lacked expertise in petroleum operations legitimizes my definition of this as a learning period. Also, that the Norwegian government was conscious about this, led to policy choices that kept them from awarding the acreage, keeping the development intensity intentionally low. Further, had the Norwegian government known that the Statfjord field was separate from the discoveries on the UK side, they may have chosen to withhold this acreage even longer, as they clearly were in no hurry to allocate it. As we saw from the analysis, the growth in the curve starts to diminish after the Statfjord discovery, which is a direct result of the policy choice of awarding acreage mainly along the UK border in order to mitigate the median line challenge.

As the 1970s came to an end, we observed that a several new large discoveries added a new rise to the curve. Had the development intensity followed the optimal path, these would have appeared immediately after the Statfjord discovery, but as a result of the policy choices taken to mitigate the median line challenge at the same time as keeping the growth in the petroleum sector under control, these discoveries were delayed. Instead we can observe a high number of medium and small discoveries in the period between the Statfjord and Gullfaks discoveries. It is expected that this increase in the curve would be observed sooner if the IOCs had the opportunity to drill these prospects at an earlier stage of the exploration phase, since these discoveries are located in the same part of the province as the Statfjord discovery and in other shallow parts, which present no challenges that could delay their discovery. Despite being located on deeper waters than the other discoveries, the Snorre and Troll II fields could have been discovered as soon as any other field, as the technological challenges related to exploratory drilling on these water depths and climates were overcome by the early 1970s.

The fourth licensing round in 1979 marked the start of a gradual softening towards the restrictive licensing policy in Norway, for which there were several reasons. The first reason was that the Norwegian petroleum sector was experiencing stagnation as investment levels dropped from over NOK 30 billion to almost half that figure from 1976 to 1978 (Al-Kasim 2006:63-64). This development scared the petroleum related industries and the labor unions, which called for speedy allocation of promising blocks in order to avert downsizing and cuts in manpower. Also, because the 'Golden Block' (the nickname for the Gullfaks discovery) was awarded to Statoil, Saga, and Norsk Hydro, the IOCs involved on the Norwegian shelf became more and more worried about their future there, as they feared Norwegian oil companies would be favored in future licensing rounds (ibid.). Therefore it may be viewed as compensation that other promising blocks were awarded simultaneously to avoid any conflict.

Another reason for the liberalization of the licensing regime was that the political climate in Norway had become more accustomed to the high influx of petroleum revenue, and the success of state participation in petroleum activities had led to the borrowing large sums of foreign capital. Society had also become accustomed to lower levels of taxation, as well as a much more expansive level of public spending. These factors resulted in political consensus to implement a higher level of activity on the Norwegian shelf (ibid.). As the prospects of these discoveries were known to the Norwegian government, but withheld for so long despite the IOCs competence to explore them sooner, I would argue that these early policy choices of the government were still directly aimed at keeping the development intensity low.

After the Troll II discovery in 1979, we observed that the curve peters out once more until the discovery of the Troll I field in 1983. Now, the timing of this discovery is another result of government influence on the development intensity. This is because the licensees expected there to be an eastern gas province based on the large areal extent of the prospect from the time before the Troll II field was proven. The first production license covered only part of the massive prospect. However, the existence of the eastern gas province was not tested until 1983, when a wildcat well proved the structure (Bolle 1988:449). According to Al-Kasim (2006) the Norwegian government had only allocated one license overlaying part of the Troll prospect and withheld the rest of the acreage. After the first Troll discovery had been appraised, the government decided to allocate the remaining three blocks covering the massive Troll prospect to the three Norwegian companies, ensuring both the growth of the Norwegian companies and securing control over the role that the field would play in the overall resource management policy (p.79). Since the field was adjacent to the Troll II discovery, there could not have been any technological challenges inhibiting the exploration of the Troll I structure, and along with the Troll II discovery, it could have been discovered significantly earlier.

The Grane, Jotun, Kvitebjørn, and Johan Sverdrup fields were all found in mature parts of the province. As seen in Figure 7, these discoveries were made in stages of the curve that otherwise show very long period of small discoveries. Had the curve followed the optimal path, these discoveries should have been observed earlier, had all conditions been perfect (information, uncertainties, technology, freedom of exploration etc.). So, is the delay of these discoveries caused by political or technical variables? The Grane field is special to this analysis, as it seems to be the first to show a field where the technological probability has been too low for the field to be discovered earlier. The NPD's record over exploration wells drilled at the prospect reveals that the discovery has been attempted regularly since 1967 after the acreage was awarded in the first licensing round. The logs reveal that the reason the drilling continued was due to the work obligation signed by the licensee (Esso), and that an oil discovery was actually abandoned in 1967, as the first on the NCS (NPD 2015E). The reason why this first discovery was abandoned is probably that it did not prove to be commercial at the time. This shows that there has been technology lag affecting this discovery, not government influence. As the size of the discovery is modest, its timing is not thought to have any real significance for the development intensity, in that it would have had little effect on the shape of the curve regardless of when it was discovered.

However, the delay of the Jotun and Kvitebjørn discoveries have been affected by government influence, as the licenses covering the areas were issued shortly before discovery (NPD 2015E). As these discoveries were made in mature parts of the province, one of the reasons for the delay is most likely the policy choice of implementing the relinquishment rule early in Norwegian licensing policy. The licensing system was constructed so that acreage left unexplored or undeveloped would be returned to the state, and IOCs had to abandon acreage one quarter at a time, so that after nine years, the state would recover half the area first granted enabling it to later award prospects unexplored or without discovery to other interested parties (Al-Kasim 2006:15-16). If an IOC was awarded acreage with more than one prospect, it is likely that it would have focused on the best prospect first, but not had time or resources to drill other prospects before having to abandon the acreage. Seeing that medium sized discoveries like these were still to be discovered is one of the reasons the NSA and APA-systems were introduced, securing the development of marginal and time-critical resources before existing infrastructure was shut down or removed. In the NPD’s annual report from 2003 this was emphasized, saying that if these resources were not developed quickly they could be lost forever (NPD 2003:7). The relinquishment policy left prospects within the APA-areas unexplored, and has resulted in the delay of such discoveries over time.

Finally, we observed the Johan Sverdrup discovery, which stands out as a much unexpected rise at the end of the curve. This field also stands out as another example of a technology lag, as exploring the prospect had been attempted several times since the mid-1960s. Since it took several attempts to prove the prospect, the technological probability must have started out low before improving over time. As the information on when the last unsuccessful attempt to drill the prospect is not readily available, it is difficult to say if the prospect could have been discovered earlier. Therefore, I would not argue that this discovery could have been made at a significantly early stage. However, had the field been discovered earlier, we could perhaps expect that the discovery of other fields would have been delayed further.

This analysis shows that although there are examples of discoveries delayed by technical variables, a clear majority of the large discoveries have been delayed by policy choices directly aimed at keeping the development intensity low by withholding promising acreage. The deviation from the ‘optimal development intensity’ is regarded as moderate at a Z2 level, as a more sub-optimal development intensity could have been observed if more of the small discoveries came between or before the larger ones.

5.2 The Norwegian Sea

In 1980, the Norwegian government felt that the technology and the understanding of petroleum operations had reached a stage where they were ready for opening the Norwegian and Barents Seas for exploration. As discussed in the previous section, the Norwegian licensing policy had already become more relaxed, but this did not mean that exploration activity would be unrestricted. The NPD and other institutions had seismically mapped these provinces thoroughly for decades. This was done to provide an important basis for opening the areas north of the 62nd parallel for future licensing. Having assessed these areas, the Norwegian authorities could better auction off each license with the proper value prospects in negotiations with the IOCs (Al-Kasim 2006:26-27).

As the first discoveries were being made in the Norwegian and Barents Seas, in the learning phases of these provinces in the early 1980s, the debate on development intensity[19] flared up once more in Norwegian politics. The most important reason for prudence and moderation in the development intensity up until the early 1980s had been the fear of overheating the economy by letting too much revenue flow into state coffers. The dependence on petroleum revenue and the decoupling of this revenue from public spending became a hot topic for political debate in 1982, as both exploration drilling and oil prices were at a peak (Al-Kasim 2006:190-191).

There was an understanding that the state had become more or less dependent on the petroleum revenue, and because of this, the domestic economy had become vulnerable to oil price fluctuations. These circumstances led to the appointment of the Tempo Committee in 1982 (also known as the Skånland Committee), whose recommendations outlined a technical solution for insulating the domestic economy from the volatile price fluctuations of the oil market (among other things). The committee proposed a petroleum fund in which Norway would use the petroleum revenue as a savings mechanism for future generations. However, the committee was skeptical to the idea, doubting the politicians' ability to restrain spending. This fund would isolate the national budget from the net petroleum revenue, thus protecting the domestic economy from starvation or overheating due to oil price fluctuations (ibid.).

The establishment of the petroleum fund (now known as the Norwegian Government Pension Fund) relieved many of the fears concerning the adverse effects of the petroleum revenue on the economy and the very active steering involved in avoiding these (ibid.). After the "tempo-committee's" recommendations for, and establishment of, a petroleum fund, the government still decided to further its policy of maintaining a moderate investment level on the NCS to sustain healthy growth in the petroleum activities by keeping the level of petroleum activity within reasonable levels (ibid.). As large field developments usually lead to higher investment

[19] The debate was on the pace, or tempo, of petroleum activities on the NCS. For our purposes, this is synonym with development intensity.

levels (as more appraisal and production wells are drilled and more infrastructure built), postponing large discoveries by still keeping the development intensity low could accomplish this.

As we observed in the previous chapter, the Norwegian Sea creaming curve exhibited one medium and one large petroleum deposit in the province after the learning phase ended in 1983. The discovery of the Heidrun field (the larger of these two) is the largest field discovered thus far in the province, which conforms well to the theory of the 'optimal development intensity'. The order of these discoveries must however be regarded as a deviation, since the medium sized Draugen discovery came first. As Figure 11 shows, a significant amount of numbered licenses were awarded in 1984, and not all of them could have been awarded to the most promising prospects (following the still restrictive licensing policy), so the order of these discoveries is determined by which licensee, or group of licensees, produced a discovery first. The fact that a prospect of the Draugen size was awarded this soon shows that the government awarded acreage thought to contain less promising prospects early, keeping the development intensity low, while other promising prospects were postponed to later points in time (as evident in the curve).

What happens after this initial rise in the curve is very interesting, as it flattens out after a few medium discoveries (the Njord and Mikkel deposits), showing only one discovery from 1987 to 1992 when the Norne field is discovered. The same happens after the Norne discovery, where the curve is flat yet again for five years with the exception of one discovery. Looking back at Figures 11 and 12, we see that the number of licenses awarded were few, but that there were still drilled many wildcat wells in the period, ruling out economic and technical variables as explanatory because the IOCs were able to drill despite not having been awarded more promising prospects. The Norne field was also discovered centrally in the province in water depths and latitudes that had been operated on several times before, and as the drilling activity remained high, economic variables also seemed to be ruled out as explanatory. The curve does not really increase again before we observe the Ormen Lange discovery in 1997.

This flat phase of the curve was influenced by another policy choice reiterating the need for lower development intensity. The need for moderation of development intensity was emphasized in the parliament's Proposition No.56 (1987-1988), where it was stated that the levels of domestic consumption and the trade account deficit had become unacceptably high due to investments made in the petroleum sector. It thus became important for the government to find ways to dampen domestic demand for foreign goods, and that increased investments in the petroleum sector (which would follow with high development intensity) was undesirable. To handle the situation, the government proposed to delay several development projects that it had under consideration, which would delay the influx of new capital. One reason for this decision was that the petroleum fund had yet to be established (Al-Kasim 2006:105-106).

Also, it was reiterated in the proposition that without interference in the operators' plans for development, all fields of substantial size would be developed within the next two to three years. If this were to happen, it would bring the annual investment level up between NOK 35-40 billion, and that such a high investment level was unrealistic to sustain beyond the early nineties even if it would be desirable to do so (ibid.). As healthy growth in investment levels is dependent on growth in petroleum activities, developing all large discoveries this early would mean that the peak of petroleum activity on the NCS would be reached too soon according to the political goals of the government.

Thus it was stated in Proposition No. 56 that it was a priority for the government to secure evenness in the level of petroleum activity. To achieve this, the government's Proposition No.56 gave priority to development of time-marginal fields that were dependent on being developed in the lifetime of infrastructure of existing infrastructure on adjacent fields, gas fields as long as there was a market for it, and developments in northern Norway when discoveries were deemed of commercial value (ibid.). The policy choice to directly stimulate growth in the North Sea curve in this period was thus at the expense of growth in the other two provinces, showing that especially discoveries in the Norwegian Sea were put on hold for a long period, thus directly influencing the development intensity of this province.

The Ormen Lange discovery was made in water depths of 800–1100 meters, a depth not surpassed on the NCS by other than the Aasta Hansteen and Linnorm discoveries, in 1997 and 2005 respectively. Even though it was possible to explore at such depths long before 1997, it is thought that the Norwegian attitude towards keeping the petroleum industry environmentally friendly and cost effective by setting high standards for technological competence (Tormodsgard 2014:48,58), made them withhold the acreage until the required technology had been properly developed and tested. Because of the policy choices in Proposition No.56 (1987-1988), it is thought that Ormen Lange could have been discovered much earlier, as the technology to drill at those depths and climates were reached long before

1997. This proves yet another piece of evidence that a HG's power to influence the development intensity can be seen by examining creaming curves.

After the Ormen Lange discovery in 1997 we observed in the previous chapter that the growth of the curve started to dissipate. The fact that there were made numerous smaller discoveries in the years following 1997 (before and after the introduction of the APA-system in 2003) shows that there were more discoveries to be made in the province, that could have been discovered earlier, but that these were again delayed by the policy choices implemented in Proposition No.56. I do however point out that their order of appearance does accord with conditional probabilities, despite some discoveries being slightly larger than others.

That discoveries were made in known areas after the Ormen Lange discovery shows that the flat periods discussed above could have been avoided without the government's restrictive policy choices. However, seeing that the activity levels did not drop during these periods, the government may have been able to prolong the exploration phase in the province, with all the social benefits that maintained activity levels entail. Because drilling activity was maintained, the government must have allocated acreage containing prospects worth exploring. However, as larger deposits were found later, these must have been withheld in favor of prospects with lower probability of being large. Hence, I argue that all significant discoveries in the Norwegian Sea province were delayed as a direct result of government policies to slow the growth in booked resources. The degree of deviation must in this case also be regarded as moderate between a Z2 and Z3 level, as there are long periods of small discoveries in the middle of the curve. Observing the long tail of small discoveries towards the end of the curve signifies that the curve could also have had a less optimal outcome, had these been discovered first.

5.3 The Barents Sea

As mentioned earlier, the Barents Sea province is special. The arctic climate, lack of infrastructure, long distances to delivery points and markets, the relatively deep waters, and the fragile environment have led the Norwegian government to be very restrictive in its licensing policy for the province (Al-Kasim 2006:102-103). Exploration activity in the Barents Sea has also been high politics in Norway, as it has been important to assert sovereignty over the region towards the Soviets/Russians, and change the trend of migration southwards by strengthening the economic potential of the northernmost areas on the mainland. Therefore, it has been important to maintain a certain level of activity (ibid.).

Additionally, there was high pressure for protection of the environment of this vulnerable area, as well as the fisheries and shipping industry, which all could become endangered by petroleum activities. To be able to declare any area in the Barents Sea suitable for petroleum activities, there first had to be conducted extensive environmental studies (ibid.).

The main problem with analyzing this province is the thirty-year long technology lag presented by insufficient capabilities in seismic mapping (Carstens 2009). This has left both the IOCs and the government without the information required to make well-educated estimations as to where all prospects have been, regardless of how good they may have been. However, the actors' perception that the seismic technology was sufficient in 1980 still led both to exploration and development, as well as policy choices affecting these. The only problem is that neither the IOCs nor the government has been able to assess the full resource potential of the province. On the other hand, the seismic mapping capacity of the time did reveal prospects that were drilled, and policy choices were implemented to deal with them.

As stated earlier in this thesis, a HG is not regarded to have any particular ability to affect the development intensity in the learning phase, but as this learning phase is so long, I argue that the Barents Sea province is exempted from this assumption. As the technology was perceived to be sufficient until at least 2009, I argue that the curve is still possible to analyze for evidence of government influence, since the IOCs and the government was able to range the *known* prospects. The policy choices implemented in the Barents Sea are much the same as in the other two provinces, but I will use this section to discuss the policy choices implemented specially for the Barents Sea, to show how the development intensity has been affected by government influence also in this province.

As we observed in the previous chapter, the curve displays some of the largest discoveries (the Snøhvit gas complex) in the first stages of the curve, which concurs with the theoretically optimal trajectory. We do however observe a long and flat section in the middle of this curve as well, half of it corresponding to that of the Norwegian Sea province (as a result of the same policy choices). As the Barents Sea was opened for exploration activity in 1980, three relatively large gas fields were discovered within the first four years. However, as the oil price dropped dramatically and the slowing down of growth in discovered oil reserves in 1985-1986, a gradual stepping up of exploration activity in the northern areas was attempting to secure the long-term resource base for this activity, but to do this both the IOCs and the government were dependent on discovering oil deposits (Al-Kasim 2006:74). The slower growth in the booked resources on the NCS continued to the late eighties, and the government stated in its Report No.46 (1986-1987) that the only province expected to yield large oil discoveries was the Barents Sea (Al-Kasim 2006:97). However, as the large oil discoveries remained to be made, the IOCs became less willing to undertake projects in the province. As we also saw in Figure 14, there were very few licenses awarded in the province from 1985 to the early 2000s, which could help explain the lack of drilling activity and discoveries in this period. The lower value of gas fields, lack of infrastructure, and long distance to markets can also have influenced the IOCs perceived break-even price, making exploration activity in this province more costly and less attractive.

Because of the political importance of the province, the Norwegian government did not want drilling activity in the province to cease completely. Therefore the government initiated the Barents Sea project in 1997 to promote exploration activity. As operating in the province was very demanding with regards to the arctic climate, and that the resources were mostly gas, IOCs were not particularly keen on taking on projects in the Barents Sea. The government decided therefore to initiate the project to avoid total stagnation in the exploration activity level. As there had been allocated approximately 60 blocks in the province since the opening in 1980, the Barents Sea project would offer 45 new blocks to the IOCs. This license allocation became a balancing act between maintaining exploration activity and protecting other industries in the far north, as well as the environment (Ministry of Petroleum and Energy 1997).

To enhance the incentives to make IOCs take on the challenges of the Barents Sea, the government also introduced strategic block allocations to the licensing system in the late eighties, linking attractive prospects in the North and Norwegian Sea provinces to commitments by the IOCs to conduct active exploration in the Barents Sea. These blocks would be chosen as the most promising structures discovered by previous NPD reconnaissance surveying. The strategic blocks came with the conditions that the government retained a large degree of freedom regarding the pace of development of potential discoveries, that there were would be conducted extensive testing and sampling, and analysis to maximize the technical value of the wells. In addition to testing for commercially viable production, it was important to maximize information on the region to further strengthen the long-term exploration effort (Al-Kasim 2006:102-103).

If these policy choices were not implemented we could perhaps expect (at least under the fiscal regime of the time) that the IOCs would not undertake exploration activity in the Barents Sea province at all. It was however a political goal for the Norwegian government that the resources in the province be discovered and evaluated, possibly adding to the resource base and simultaneously extending the estimated time-horizon of operations. As we saw in the previous chapter (section 4.5), most of the discoveries in the Barents Sea province have also been deemed unlikely to be developed, mostly due to high gas concentrations and the costs involved in transporting these to market. As the IOCs had little confidence in the geological probability of the province (illustrated by the lack of willingness to take on projects), a few discoveries could perhaps be expected, but that these could have been abandoned if they proved to be gas occurrences. Since the province is so far away from the European gas market, liquefying and transporting the gas or building pipelines would probably have been viewed as being too big an expense and too risky.

In 2000 we observed the other only developed field in the Barents Sea, the Goliat discovery. The acreage was awarded in the Barents Sea Project in 1997, but was not discovered until 2000 (Eni Norge n.d.). That the Barents Sea Project resulted in this discovery shows that this policy choice bore some fruits, although as limited as they may have been. After the Goliat discovery, we observed that the curve flattened completely once again. This second period was, as we saw in the previous chapter (section 4.5.3), due to the lack of drilling activity.

After the introduction of the APA-system in 2003, we observed a drastic increase in the overall number of licenses awarded and that the curve again started to rise. Even though most of these discoveries proved not to be commercial, it did lead to discoveries like the large Johan Castberg field and surrounding discoveries, which is regarded to be one of the most promising discoveries in a long time. In recent years, the optimism in the Norwegian Sea has declined as deep-water wells have been disappointing, while the Johan Castberg discovery has upgraded the resource potential of the Barents Sea and given rise to new optimisms, turning the province into a hotspot (Carstens 2013A, 2013B). Also, the new understanding brought about by geological learning through the Goliat and Nucula discoveries has shown that the seismic technology has been lagging, but that the lag was now being eliminated. This means that the Barents Sea curve will very likely continue to rise. Additionally, much of the acreage in the Barents Sea remains withheld for exploration, which means that if these areas are opened, new and possibly large discoveries can be made.

In this context I argue that most of the development intensity in the Barents Sea was driven by government influence, but in the opposite way of the other two provinces. Instead of postponing discoveries in the Barents Sea, the government stimulated them. On the other hand, the government did restrict the exploration activity to certain areas for various reasons, which could have provided disincentives for the IOCs. I argue that the technology for operating in the province was sufficient, but that the information base was inadequate. Because of the special attributes and challenges of the Barents Sea province, and that much of the acreage remains unexplored, I argue that the history of petroleum operations in the province has been one long learning period, as many of the areas have been withheld because of the government's cautiousness. As many new areas are being opened for exploration, we can expect that the curve will continue to increase, and that the probability of making new large discoveries is fairly good, both in frontier and mature areas. As the Norwegian petroleum industry is reliant on making new discoveries to sustain growth rates, and the other provinces have been thoroughly explored, we can perhaps expect that the Barents Sea curve will follow a more optimal trajectory in the years to come. The only other policy consideration that can threaten this is environmental protections in further withholding acreage.

The government's persistence in maintaining exploration activity in the province seems to have paid off, as the development of new seismic competence has in recent years revealed very promising petroleum discoveries that are predicted to make the province very attractive in the coming years. Had the government given up on the province, this technology may never have been developed, and the potential of the province remained unknown. The 'observed development intensity' for this province would probably have followed an even less optimal path in the absence of government influence, but as restrictions on exploration activity has hindered the IOCs from exploring the whole province, an even higher development intensity could have been achieved. For now, the curve has followed a path of moderate development intensity similar to that of Z3, because the discoveries have been relatively small and far between, making the curve follow what seems to be more of a linear direction. However, as the province is foretold to show new and possibly large discoveries in the future, but still under some degree of restriction, it is likely that the curve will follow a path similar to the Z4 curve in Figure 6.

5.4 Summary

The Norwegian government's goal of maintaining a prudent and moderate development intensity through a restrictive licensing policy seems to have postponed the discovery of large petroleum deposits. The political fear of falling prey to the resource curse or the Dutch disease motivated for slower development intensity than what is regarded as optimal, and the Norwegian government therefore wanted to avoid a quick succession of large discoveries in the early stages of the exploration phase (Al-Kasim 2006:38-39,73-74). The small degree of variation between the provinces shows that the policy choices made by the Norwegian government has affected all of them, ceteris paribus, and resulted in a moderate level of development intensity in all provinces.

For the purposes of resource management, this seems to have been very wise, as the government avoided the adverse effects of the massive influx of petroleum revenue in the early phases, while still managing to develop marginal and time critical resources towards the end by amending fiscal constraints and exploration regulations in mature parts of the provinces. Instead of allowing the development intensity to follow an optimal trajectory, it may have managed to extend the period of operations by delaying many of the major discoveries. Had all the major discoveries been found in the beginning of the Norwegian petroleum fairy tale, by allowing unrestrained exploration and development, one would expect that the IOCs could have lost interest sooner. As there were (and is) still promising areas to be explored, the government may have managed to maintain the IOCs interests in the shelf.

In 2014, the NPD estimated that 21% of the total reserves on the NCS had yet to be discovered (Tormodsgard 2014:22). This means that we can possibly expect the curves to show new discoveries in the following years, even though the era of giant discoveries are thought to be over. The Norwegian government has now opened most of the North Sea, the Norwegian Sea, and the southern Barents Sea for exploration, where the estimated undiscovered resources are respectively 28, 29, and 43 % (Tormodsgard 2014:34). Because of this, there is still a chance that large discoveries will appear once again in the creaming curves.

As seen with the Barents Sea province, IOCs do make mistakes regarding conditional probabilities in prospect ranking, based on interpretation of seismic data. This means that there can be technological lags that prevent prospects from being identified and interpreted correctly today, but could be interpreted in a different way tomorrow with new technological advancements. The frontier areas on the NCS today are the northernmost and deeper parts of the Norwegian Sea, large parts of the Barents Sea, and small areas in the North Sea. Of these areas the entire northern part of the Barents Sea, the northeastern Norwegian Sea, Skagerak, and the area surrounding Jan Mayen, remain to be opened for exploration activity. Before opening these areas, the Storting must evaluate the possible social, economic, and environmental impact of petroleum operations in these areas (Tormodsgard 2014:37).

6.0 Conclusion

The most important political goal for the Norwegian government has been to develop its resource base in a prudent and moderate manner in order to shelter the economy, maintain stability in the employment figures, help build experience, and to improve environmentally friendly practices for future areas. As stated earlier, the Norwegian government was very cautious regarding the level of development intensity, and feared falling into the same trap as the Dutch had done in the early 1960s, losing control over how much revenue was generated and how fast the petroleum sector grew. As the Norwegian government's bargaining position quickly grew in strength, it was able to exert influence over how high or low the level of development intensity on the NCS was going to be. Through clever licensing and regulations, the Norwegian government managed to portion the large discoveries on the NCS over a much longer period than what theory suggest it would have in an unregulated petroleum province.

The existing resource management and energy policy literature attribute the rate of growth in booked resources chiefly to economical and technical variables, often overlooking the political variables in play. I have in this thesis provided a political science perspective showing that the growth rates in booked resources in the Norwegian case were mainly affected by licensing policy and regulatory measures intended to keep the development intensity low. As we have seen in the two previous chapters, the NCS creaming curves all deviate to a moderate degree from what we assume to be the 'optimal development intensity' because the Norwegian government allowed exploration activity sporadically across the provinces, but withheld acreage thought to contain large deposits for longer periods of time. Hence, I argue that the deviations from the 'optimal development intensity' for each of the curves can to a very large extent be attributed to political factors, since there seems to have been very few examples of petroleum deposits which discovery has been belated by other variables.

To answer my hypothesis from the beginning of this thesis; I argue that creaming curves *can* be used as an indicator to measure government influence over the development intensity in a petroleum province, and that when all other theoretically relevant variables are controlled for, we have evidence of this. As this thesis tries to capture the bigger picture, there is a chance that unknown variables could have had an effect on the development intensity, or that other important aspects have been simplified. However, with this in mind, I do argue that the results of this thesis are valid.

Since the Norwegian government is still withholding some of the exploration acreage, we can expect that the creaming curve for each province will continue to increase, but that the probability for new large discoveries are low. As Statistics Norway points out, the petroleum activity levels are estimated to continue to increase for a couple of years, but that it will start to decline shortly after that (Statistisk Sentralbyrå 2013:4). This is also evident in the petroleum industry, where the major IOCs are starting to sell their assets on the North Sea, and an estimated 15.000 jobs have disappeared in the Norwegian petroleum sector the last couple of years (Dagens Næringsliv 2015). Even though the government has recently offered 46 blocks with new exploration acreage in frontier and APA-areas, some of the players in the industry are afraid that the restrictive resource management policy the Norwegian government still follows is suffocating the industry (Taraldsen 2015; Lorentzen 2015; Frafjord 2015). The industry’s mood does however fluctuate, and in 2013 many IOCs were flocking to new exploration acreage in the Barents Sea after new discoveries were made, and some analysts think that there will come a new golden age for the Norwegian petroleum industry (Carstens 2013A; Ånestad 2015). If new discoveries are made, we can expect that the mood will turn towards optimism once again, and there are still areas on the NCS that have yet to be explored.

This thesis provides a foundation for future comparative research on how states manage their petroleum resources. I suggest that further research should compare creaming curves in offshore petroleum provinces under different regulatory regimes, in order to investigate the relationship between the regimes and the effects on development intensity. By researching this on a comparative scale, we can further our understanding of how the growth rate in booked petroleum resources can be influenced by political factors. Building on such research, it may be possible to infer causation between the rate of growth in booked resources and the success or failure in resource management. I also recommend quantifying the requisite data for developing a statistical indicator that can effectively measure the effects of government influence on development intensity, which could be very useful for future comparative research. Another interesting subject for future research would be to investigate whether variation in the bargaining strength of a HG correlates with variation in development intensity over time.

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8.0 Appendix

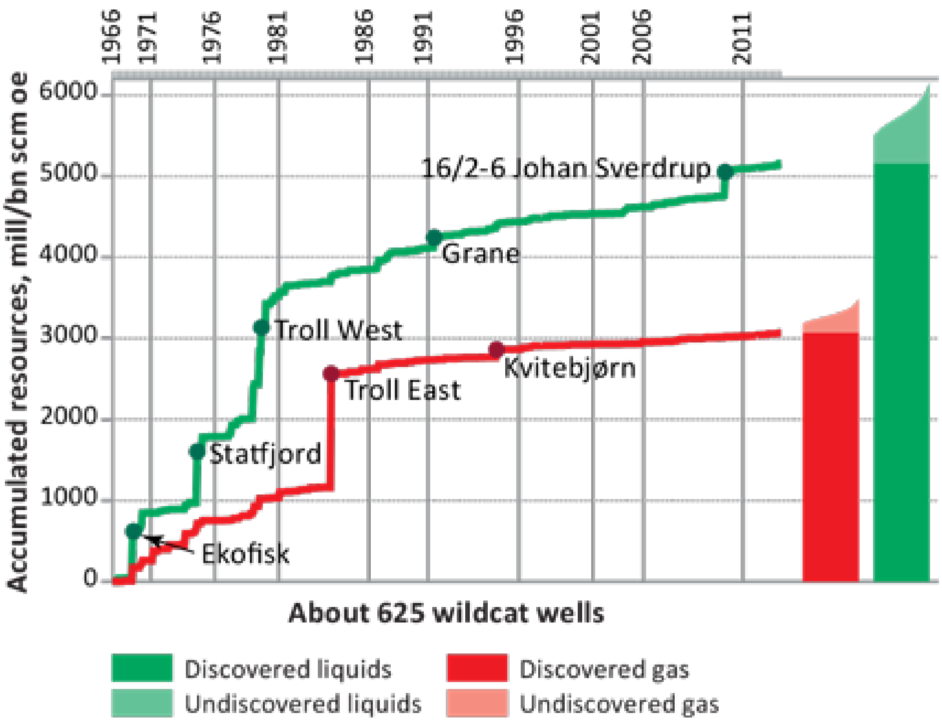


Figure A1 North Sea creaming curve (NPD 2013:35)

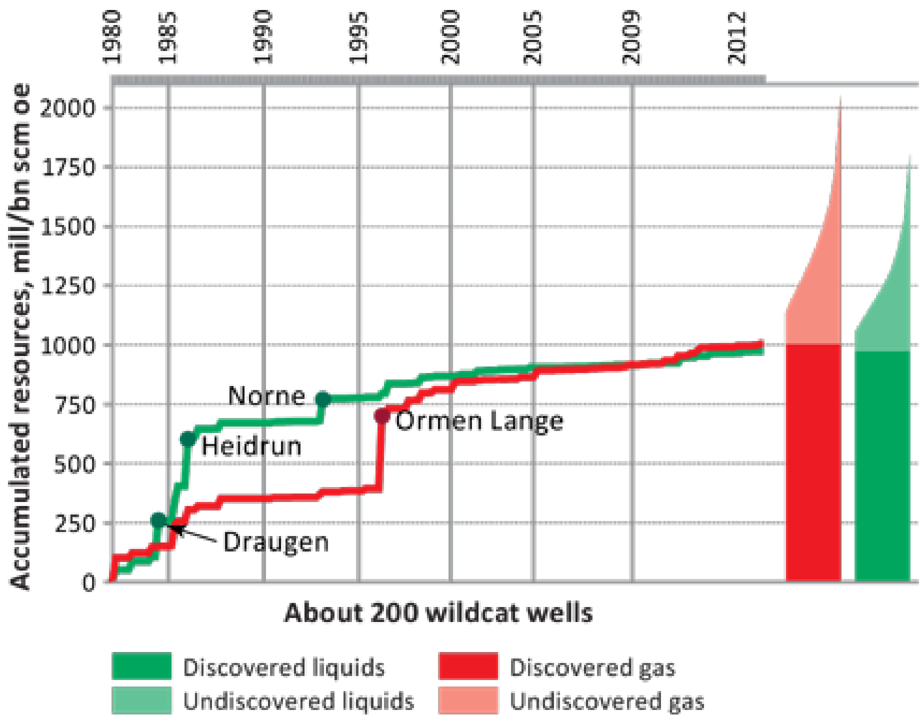


Figure A2 Norwegian Sea creaming curve (NPD 2013:34)

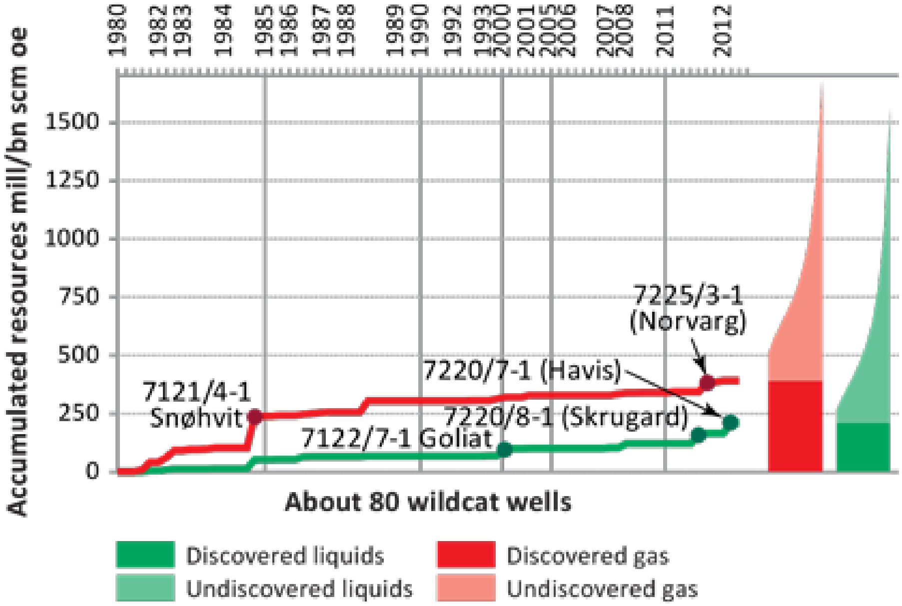


Figure A3 Barents Sea creaming curve (NPD 2013:32)

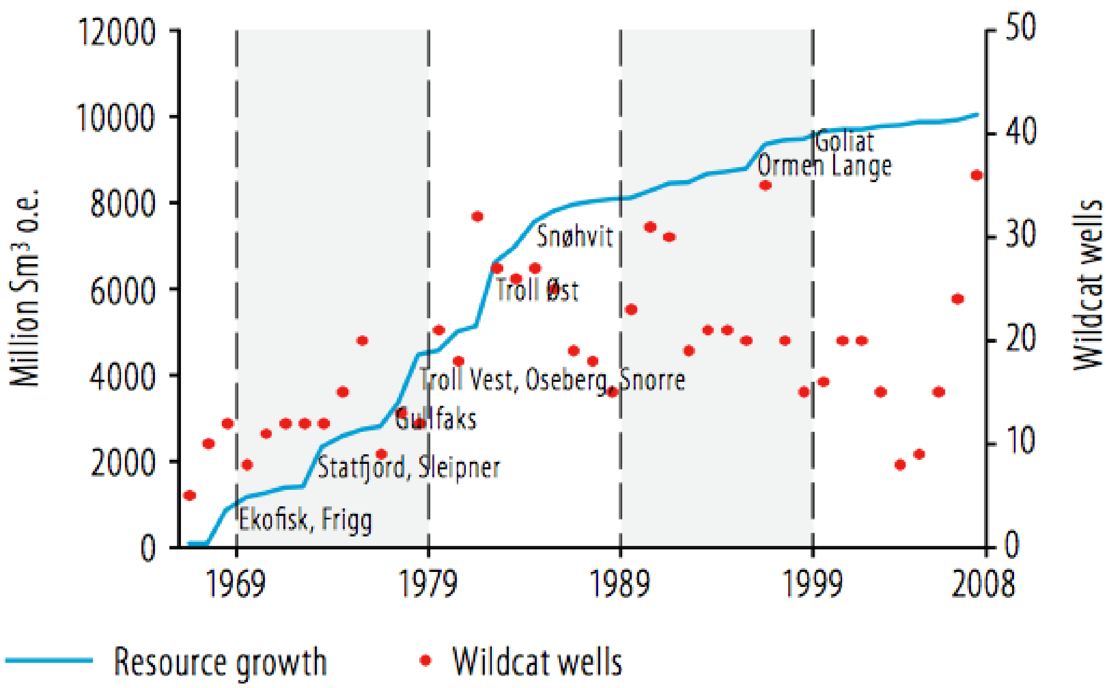


Figure A4 Growth in resources and number of wildcat wells drilled from 1969 to 2008 (NPD 2009:31)

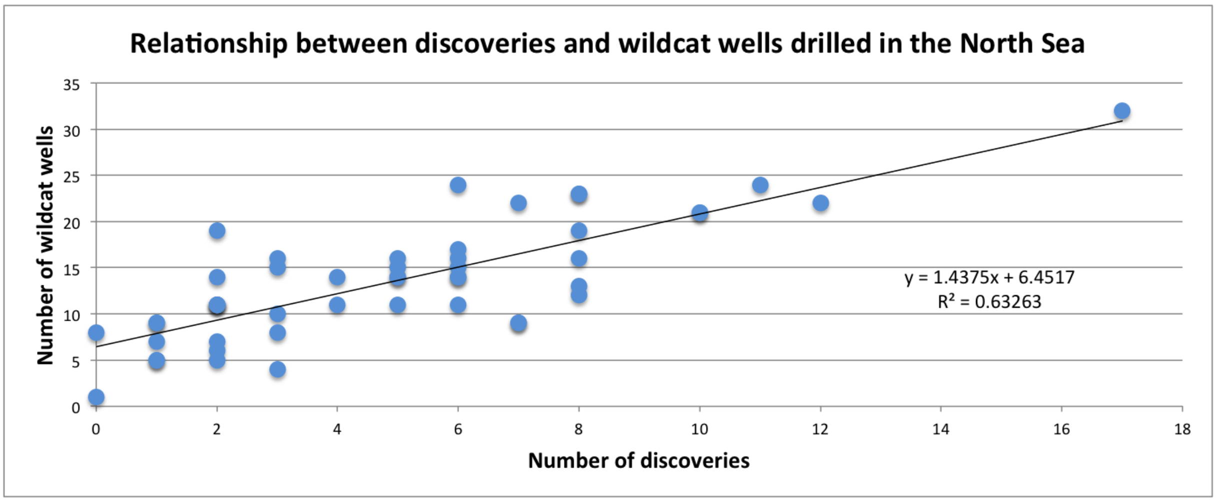


Figure A5 Statistical relationship between discoveries and wildcat wells in the North Sea (NPD 2015B)

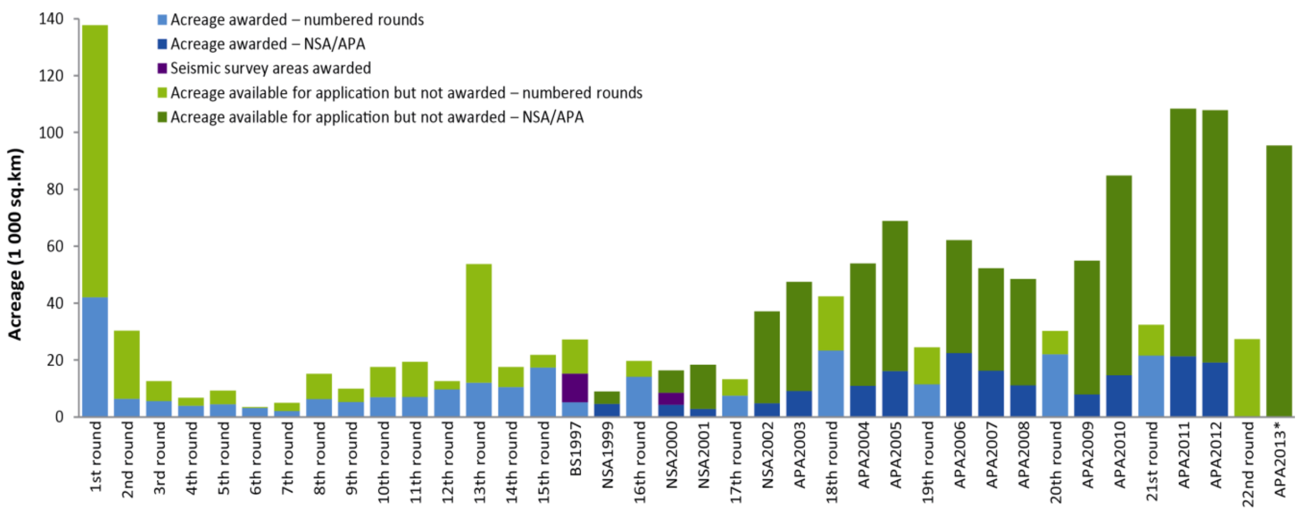


Figure A6 Acreage offered and awarded on the NCS at March 15, 2013 (NPD 2013:13)

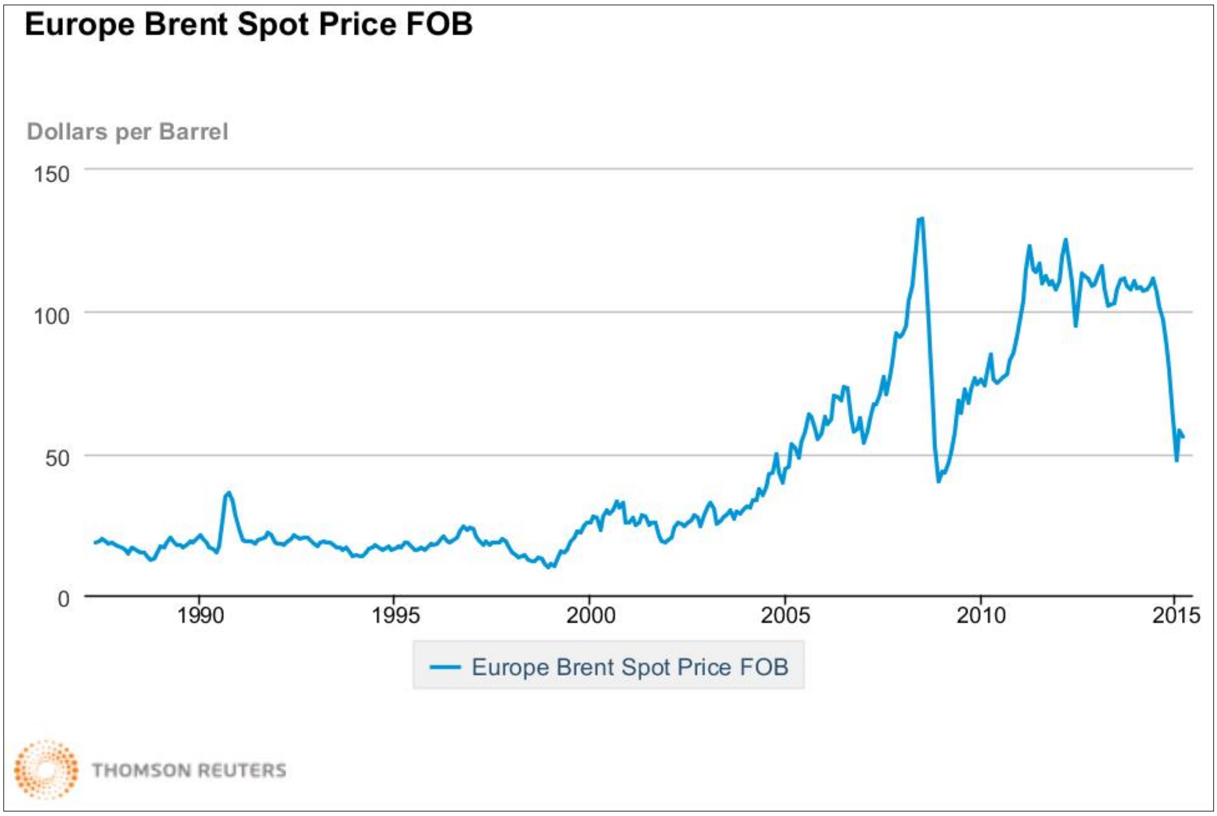
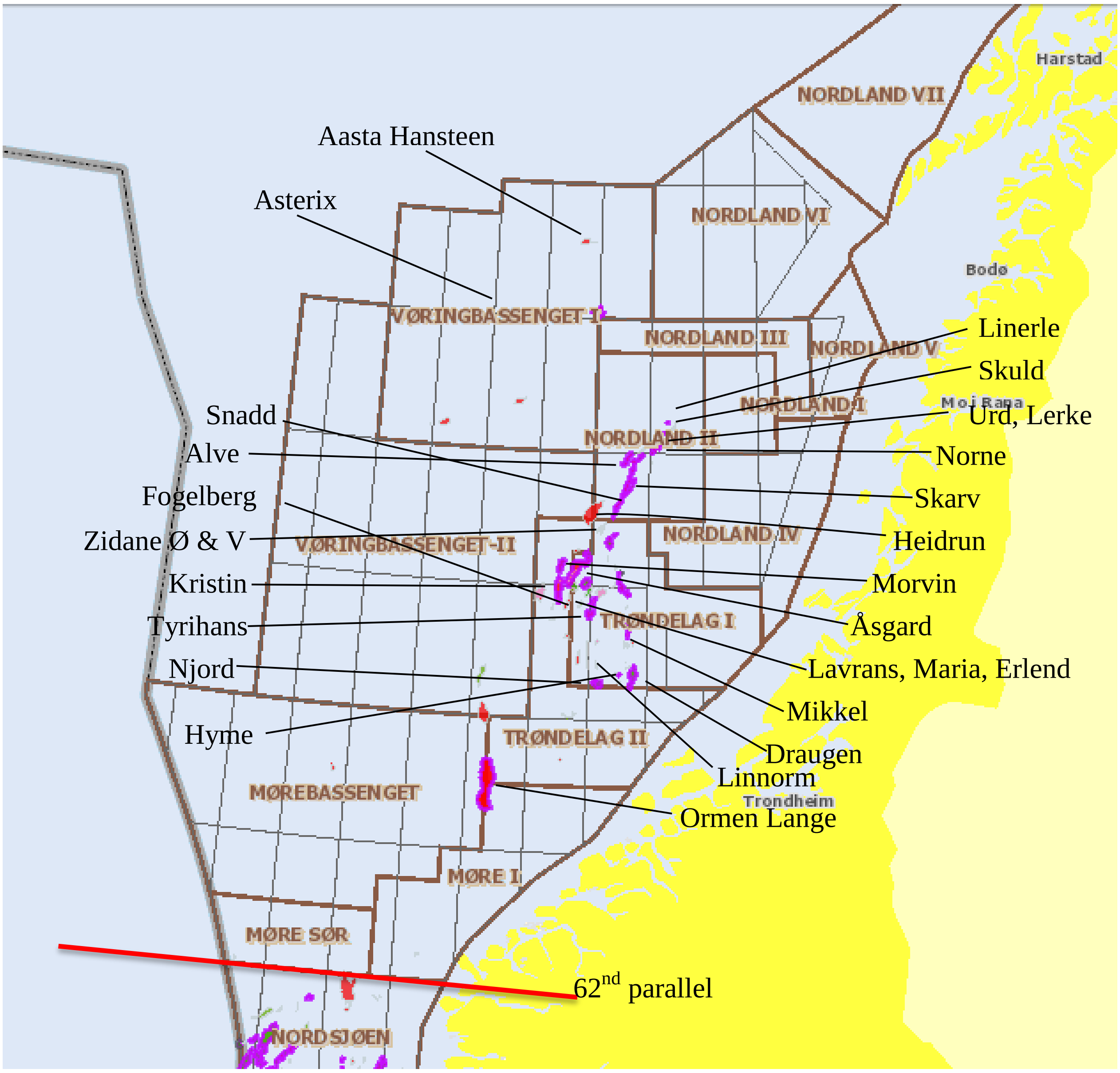
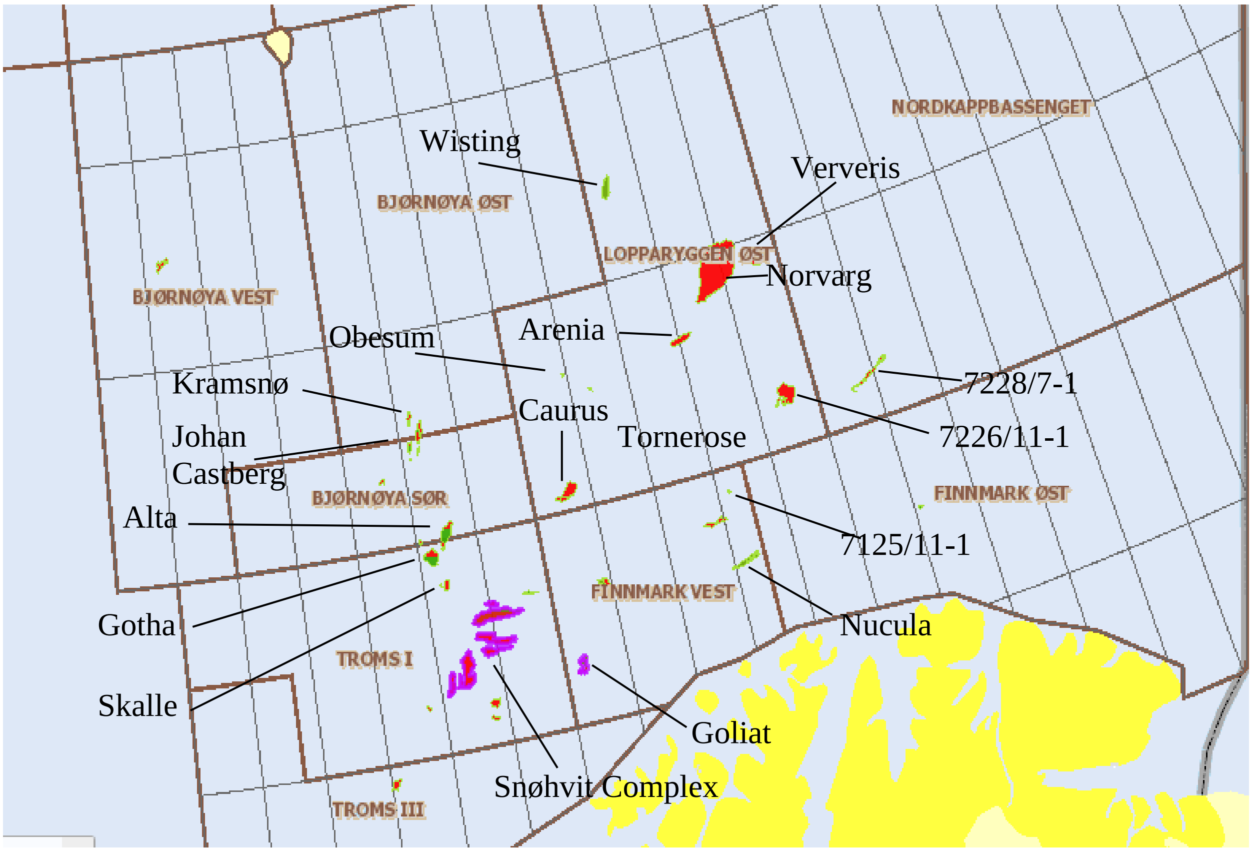


Figure A7 European Brent Spot Price (EIA 2015)

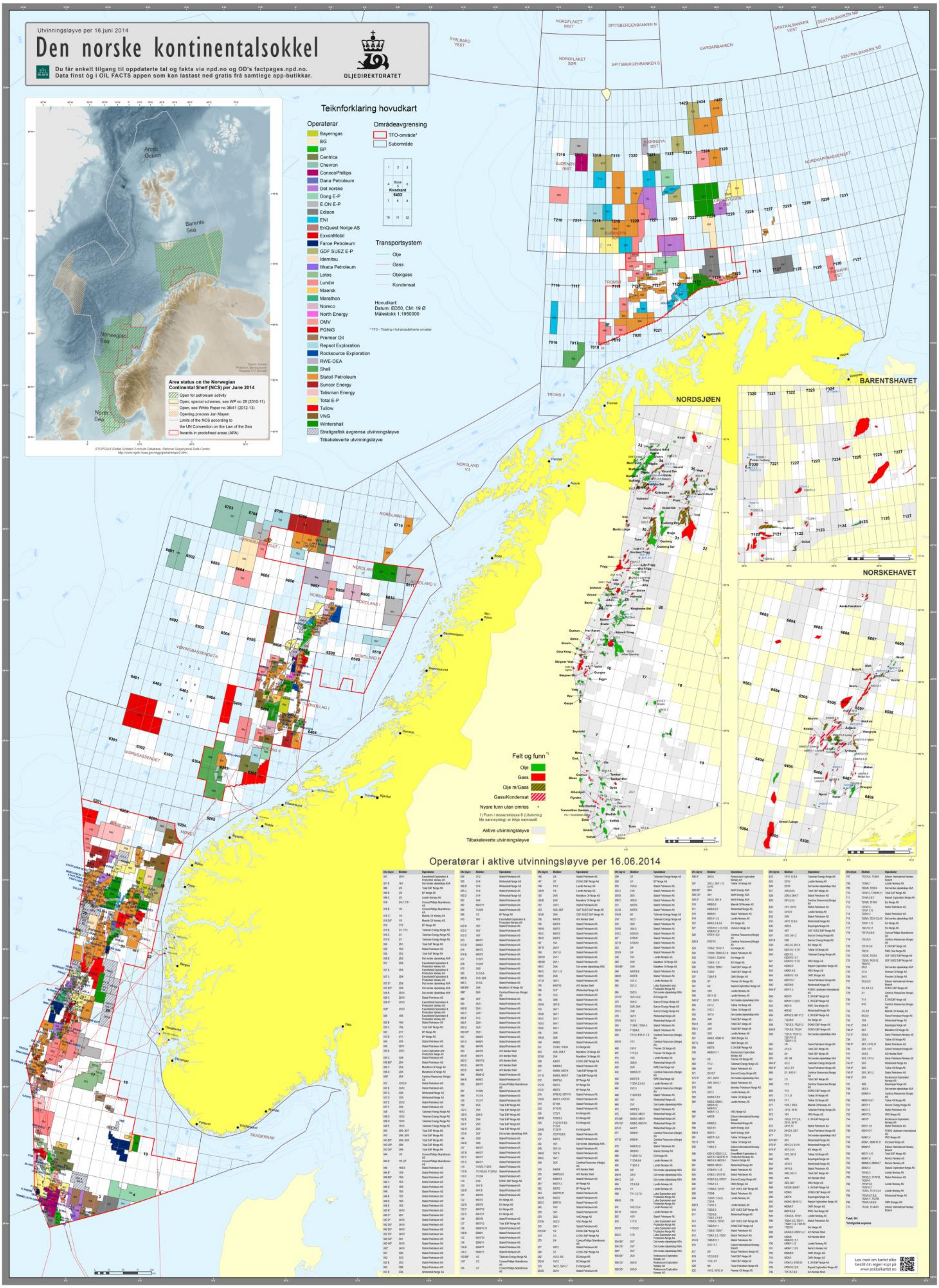
Map A1 Location of discoveries in the North Sea, edited screenshot (NPD 2014B)



Map A2 Location of discoveries in the Norwegian Sea, edited screenshot (NPD 2014B)



Map A3 Location of discoveries in the Barents Sea, edited screenshot (NPD 2014B)



Map A4 The Norwegian Continental Shelf (NPD 2014A)