Hydrocarbons in Greenland

– Prospects for the Greenlandic Economy

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Abstract

Title:	Hydrocarbons in Greenland – Prospects for the Greenlandic Economy
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Research Question:	How favourable are the geological, economic and institutional conditions for building a self-sustaining economy in Greenland based on its hydrocarbon resources?
Method:	As this thesis assesses geological, economic and institutional conditions, theory and methodology is assembled from multiple scientific disciplines, primarily hydrocarbon geology, institutional economics and finance. The work process with this thesis has been iterative as we have adapted the question when new information has become available. We have spent four weeks in Greenland where we visited the capital Nuuk and the town Sisimiut.
Conclusion:	We show that the geological conditions are favourable, but that the economic and institutional conditions can be improved. The geological conclusions are encouraging. Greenland has a 50% probability of finding at least 29% of Norway's ultimately recoverable resources and a 95% probability of finding at least 8%. This is a significant number considering the size of the Greenlandic population, which is only 1% of the Norwegian. We therefore conclude that there are favourable geological conditions to make Greenland self-sustaining. The economic conclusions show that there is a 61% probability of replacing the block grant with current oil prices. This indicates that it is possible that Greenland can become self-sustaining. However, replacing the block grant is not enough to keep the government budget balanced assuming current poli-

cies. Additionally, the possibility for Greenland to become significantly richer is negligible at current oil prices. We therefore conclude that the current optimism surrounding the oil industry is exaggerated.

Large direct government oil income affects an economy through the Dutch disease, which decreases the competitiveness of the exporting industry. We find that Greenland already suffers from Dutch disease and that it is caused by the block grant. An oil economy would probably retain, or aggravate, these effects.

The resource curse may cause economic growth to be lower in natural resource rich countries. Collier & Hoeffler (2005) find that scrutiny, and especially press freedom, can prevent the curse. There are no prior investigations or indices on the institutional quality in Greenland from this perspective. Therefore, we make a qualitative analysis of this matter through interviews with key officials and compilation of related publications.

We show that scrutiny in Greenland is functioning and improving but that there are some problems left. Primarily, the administration can be made more transparent and the media can be strengthened. Our conclusion is that it is impossible to guarantee that the institutional situation is sufficient to avoid the resource curse. The institutional capabilities are especially important as the Greenlandic Mineral Resource Fund will be central to control the Dutch disease.

Recommendations: Based on our results, we recommend policymakers in Greenland to lower the expectations on the oil industry and to try to lower the risk exposure towards it. We recommend a focus on improving institutions, as this will have positive effects regardless of how much oil is found. Finally, we recommend that the Greenlandic Mineral Resource Fund is used restrictively and that the management of it is kept separated from the government budget. This is important to manage the Dutch disease and to make sure that the resources will benefit also future generations.

Keywords: Greenland, oil, hydrocarbons, resource curse, Dutch disease

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This master thesis is written at the Technology Management programme at Lund University/Lund Institute of Technology in Sweden. It is targeted to anyone interested or concerned by the economic development in Greenland as well as to students and teachers at the Technology Management programme. We hope that our work is both theoretically interesting, in particular in relation to institutional economics, as well as practically relevant for stakeholders and policymakers in Greenland.

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1 Introduction

Greenland is a country between the traditional and the modern, a society bordering on the possible. It is an old colony, which mixes aspirations for independence with economic dependence on the old metropolis, Denmark. It is a country resembling a Nordic welfare state, but with inequality on par with Mexico and the United States. For the wider world it might be most known for being one of the places on earth where the effects of climate change are most dramatically evident. Soon, however, Greenland might be standing at the centre of the world's attention for another reason, namely for it's natural resources in general, and oil in particular.

In Greenland, the possibility of finding oil permeates society on all levels. Large oil findings could make it possible for the country to finally reach complete independence from Denmark. It could also provide employment and bring economic development to an economy that is today reliant on fisheries and a large yearly subsidy, the block grant, from Denmark. Finding oil is something that many states would desire, but the combination of a vast pristine area and a lilliputian population makes the situation in Greenland unique. Will Greenland become an Inuit version of the Middle East where the traditional Greenlandic hunting grounds make way for oil refineries, financial centres and glacier casinos? The perspectives are mind-boggling and the future for the population looks exciting.

1.1 Problem Discussion

There are high hopes in Greenland that the country will go from being a nation of fishermen to a nation of oil producers. But what do we really know about the prospects? Most of the information comes from three sources, which all frame their message in different ways.

The geologists at the US Geological Survey, USGS, perform assessments of the potential oil resources in the world. They show that it is likely that there are vast oil resources to be found in the waters offshore Greenland. This data, however, only shows the likely existence of oil and not how much of it will actually be produced. Additionally, the data is presented as geological data with an outcome distribution. These two factors make the data hard to use for economic models.

The authority handling the oil in Greenland is the Bureau of Minerals and Petroleum (BMP). The BMP prefers to keep a low profile and tries not to raise expectations. Therefore it has officially avoided to release estimations of how much the oil could be worth to Greenland. Instead, the BMP has made calculations available only to show how the contracts with the oil companies would work and what the share for Greenland would be. These calculations imply certain finding sizes but these are not founded in the geological data.

The politicians in Greenland communicate clearly that the mineral resource sector is the future for the Greenlandic economy and that it will make further independence possible. The political discussion is, however, kept on a visionary level. This makes it hard to assess how realistic these visions are.

The geologists, the authorities and the politicians all provide information of different nature and answer different questions. This makes it hard to combine and complete the jigsaw puzzle. It is therefore difficult for the public and other interested parties to understand what is realistic to expect and if the visions that the politicians deliver are credible. This thesis makes a first attempt at combining these pieces of information.

We analyse what Greenland can realistically expect from oil in the future, given the information available today. In order to do this, we choose three conditions that need to be fulfilled in order to achieve a self-sustaining oil economy in Greenland. First, there has to be oil present. Secondly, producing this oil will have to render sufficient profit to make Greenland self-sustaining. Finally, the institutions in Greenland will have to be strong enough to manage the resources efficiently. In this thesis, we assess how favourable these three conditions are.

1.2 Research Question

How favourable are the (a) geological, (b) economic and (c) institutional conditions for building a self-sustaining economy in Greenland based on its hydrocarbon resources?

where by *geological conditions*, we mean how large the technically recoverable hydrocarbon resources in Greenland are.

where by *economic conditions*, we mean how well the government income from the resources suffices to meet Greenland's financing needs.

where by *institutional conditions*, we mean how well prepared the institutions in Greenland are to manage the resource curse.

where by *self-sustaining economy*, we mean an economy that achieves independence from external financial contribution without a drastic reduction in the standard of living, making further political independence possible.

1.3 Purpose

The purpose of this thesis is to:

i) provide a basis for an informed public debate about Greenland and oil
ii) show the need to include geological, economic *and* institutional perspectives in the public debate
iii) encourage further investigations about Greenland and oil by authorities and external parties

1.4 Target Audience

This thesis targets anyone interested in the future economic development in Greenland. Specifically, it targets stakeholders in a potential Greenlandic oil industry as well as policymakers in Greenland.

1.5 Method

This thesis assesses geological, economic and institutional conditions. Theory and methodology is therefore assembled from multiple scientific disciplines, primarily hydrocarbon geology, institutional economics and finance.

In order to preserve the theme of the thesis, the geological, financial and institutional economic discussions are kept in separate chapters. Theory and methodology are presented in connection with each analysis.

The work process with this thesis has been iterative. This means that the research question has been reshaped during the work process to incorporate new information from interviews as well as new data. Since data about Greenland is scarce and scattered, new information has continually reshaped the work. As the purpose of this thesis is to provide basis for an informed discussion about Greenland and oil, the question has also been adapted to fit the knowledge gaps that were found during the work process and interviews.

The work has been carried out primarily in Lund, Sweden. We have also spent four weeks in Greenland, visiting the capital Nuuk and the town Sisimiut. In addition to making interviews possible, the visit to Greenland has given us a deeper understanding of Greenlandic society.

In Greenland, we have carried out interviews with a total of 16 persons. In addition to this we have also carried out three interviews in Copenhagen and two in Sweden. We have also conducted e-mail interviews with five persons. We have tried to interview as many policymakers and stakeholders as possible, as well as people with insights into Greenlandic society and the geological conditions in Greenland. To achieve this, we have contacted many people to see if they were interested in talking to us. We have been positively surprised by the response. The final interviewees cover a wide spectrum including politicians, representatives from authorities, researchers, NGOs, industry, oil experts, journalists etc. All interviewees are mentioned in the reference list. Not everyone is directly cited in the thesis. All of them have, however, contributed to our understanding and work.

The first interviews conducted were generally more exploratory, i.e. performed to get an understanding of the topic, to test working hypotheses, and to find new interesting interviewees. Later interviews were more focused on gathering data. Because of this and since the interviews were with representatives from very different parts of society, they were conducted in an unstructured fashion. Before each interview, we prepared questions and discussed the purpose of the interview. In all interviews, both the authors of this thesis were present. We took notes during the interviews and discussed them afterwards. In some cases, e.g. when time was short, we also recorded the interviews to recap them later. When we received the same information through both interviews and published sources, we have chosen to cite the published source.

In Sisimiut, we participated in a public meeting (borgermøde) with the Greenlandic premier Kuupik Kleist, Minister for Finances Maliina Abelsen, Minister for Industry and Mineral Resources Ove Karl Berthelsen and the Minister for Fisheries, Hunting and Agriculture Ane Hansen on March 12, 2012.

Through the work with this thesis, we have used reports from the Greenlandic authorities and the Government of Greenland to provide Greenland-specific data about the oil prospects, legal arrangements and processes. Economic calculations have been based on the work of Paldam (1994) and the Tax and Welfare Commission (2011). For statistics, we have used data from Statistics Greenland and Denmark Statistics. The USGS has also been a major source for geological data. For general information about the oil market and economic development global organisations such as the IMF and the IEA has been used. Additionally, oil market data has been retrieved from the oil company BP.

In many cases, it has been possible to verify the data, as it has been available from different independent sources. In the case of the geological data, we are reliant on the USGS. However, this incorporates earlier research and is based on a broad international scientific collaboration, particularly with the Geological Survey of Denmark and Greenland (GEUS). This makes it a reliable source of information.

When making assumptions about uncertain quantitative parameters we have handled this in three ways. When we have been fairly certain, we have used the most reasonable value. When we have been uncertain and the impact of the parameter on the result has been relatively small, we have used an optimistic value. When we have been uncertain and the impact of the parameter on the result has been large, we have used a spectrum of values to provide a sensitivity analysis. This approach is summarised in Figure 1.

	Uncertain	Relatively certain
High impact	Spectrum of values	Most reasonable value
Low impact	Optimistic value	

Figure 1. Our parameter estimation methodology

1.6 Outline

The question is answered by analysing the geological, economic and institutional conditions in Greenland as they are known today. For Greenland to succeed in building a self-sustaining economy based on hydrocarbons, all these factors have an impact, and deserve attention. The thesis is structured around these three assessments. A concluding summary is given at the end of the thesis, followed by recommendations for policymakers. As the thesis is cross-disciplinary, theory is presented in connection with each section. This makes it easier to distinguish the technical framework and calculations from the institutional assessment.

In chapter 2, we give a short background to Greenland and the Greenlandic economy as of today. We do this in order to provide an understanding of this rather special country, and to form a backdrop for the economic and institutional discussions that follow later on.

In chapter 3, we assess the geological conditions for achieving a self-sustaining economy in Greenland based on hydrocarbons. Firstly, we introduce hydrocarbon geology. This includes a description of the geological prerequisites that are required to find hydrocarbons. Secondly, we discuss hydrocarbon exploration, with a special focus on the exploration process in Greenland. Thirdly, we review the challenges to perform oil exploitation in Greenland to determine the feasibility of production. Finally, we estimate the technically recoverable hydrocarbon resources in Greenland to quantify the potential.

In chapter 4, we assess the economic conditions for achieving a self-sustaining economy in Greenland based on hydrocarbons. Firstly, we quantify the expected direct government oil income. Secondly, we present four scenarios for a self-sustaining Greenlandic economy and assess the probabilities for them. Thirdly, we introduce the concept of the Dutch disease and income volatility. We relate these to the current situation in Greenland and discuss how they can be managed. Finally, we estimate the Dutch disease effects of the scenarios.

In chapter 5, we apply an institutional perspective. Firstly, we revisit the concept of the resource curse with a special focus on rent-seeking. Secondly, we discuss how the resource curse can be managed through institutions. Thirdly, we analyse the Greenlandic institutions that are central to managing the resource curse.

In chapter 6, we answer the research question by summing up the analyses from earlier chapters.

In chapter 7, we make recommendations for how Greenland can improve the chances of achieving a self-sustaining economy based on its hydrocarbon resources.

Chapter 3 and 4 use mostly quantitative methodology and secondary data to arrive at their respective conclusions. In contrast, chapter 5 uses qualitative methodology and primary data, as very little relevant data is available. This results in that the conclusions from chapter 3 and 4 are stronger and more explicit as they are backed up by work of other researchers. The conclusions in chapter 5 are less definitive and more work should be encouraged in this field.

1.7 Delimitations

This thesis does not consider other mineral resources than hydrocarbons. Neither does it consider natural gas nor the environmental concerns surrounding oil extraction.

There are other growth industries, except hydrocarbons, that might give significant contributions to the Greenlandic economy in the future. Mineral extraction and other large-scale projects have been proposed. These have, however, been part of the Greenlandic economy for a much longer time. The hydrocarbon sector would therefore mean a larger shift for the Greenlandic economy, especially as the potential value is large. While the technical discussion is only relevant to the hydrocarbon sector, conclusions from the economic and institutional analyses can also be applied to other sectors.

As we show in 3.4.1, gas production in Greenland is not economically viable and is therefore excluded.

We do not include the risk for large-scale environmental impact. This is a well-known problem, and an extreme event has the potential to affect not only the environment but also the economic development in Greenland significantly. The risk for environmental impact should therefore be an important consideration in policy-making. It is, however, not suitable to involve in this report as the economic consequences of an extreme event would have unforeseeable consequences that are hard to estimate. Additionally, environmental issues related to oil production are already discussed in Greenland.

2 A Short Introduction to Greenland

Greenland is the world's largest island with an area of 2.2 million square kilometres of which more than 80% are covered with ice, the world's second largest ice mass after Antarctica. Greenland has a population of about 57,000 and the capital Nuuk has a population of around 15,000. The towns in Greenland are not connected by roads, so transport is done by air or by sea.

In order to provide an understanding of the country, the next section presents a historical introduction. This is followed by a section describing the political situation and the relationship with Denmark. We then review the economy and discuss the future challenges. The chapter concludes by explaining why oil is especially attractive in a Greenlandic context.

2.1 Historical Introduction

Greenland was first populated in 2000 BCE and there is evidence of several migration waves since then. The Greenlandic indigenous population, the Inuit, formed advanced hunting cultures that were organised around settlements and tightly held family groups. Cooperation and responsibility for the group was an important feature in Inuit culture, and the catch was shared equally among the families. (Karlsson, 2008)

The first Nordic people that arrived in Greenland came in the 900s CE and formed settlements that were populated by up to 4000 people at their peak, before being abandoned in the 14th century. In the 17th century, Greenland started to become interesting for the Europeans once again. This time because of the large whale population, which was economically valuable. In 1721, a Norwegian trade company was established, and a colonial period started. The trade was soon taken over by Denmark, that established the state monopoly Kongelige Grønlandske Handel (KGH) in 1778. KGH was in control not only of trade but also of the administration until 1912. The administration and the church tried to shelter the Greenlandic as much as possible from the influence of capitalism and world development. (Paldam, 1994) The Greenlandic Inuit therefore continued to live in a more or less traditional way until the 1900s. (Karlsson, 2008)

The Danish approach to Greenland changed drastically during the 1950s and 60s as Greenland was taken up as a county within Denmark and a modernisation process was initiated. This meant that the Greenlandic Inuit were more or less involuntarily moved from their traditional hunting grounds into cities and newly constructed apartments and houses. Large investments were made in the industrial sector, particularly in cod fishing. (Dahl, 1986) The idea was to kick-start a Greenlandic economy and to found industries which could render a private sector. As private investment was scarce despite attempts to make Danes invest in Greenland, the state took responsibility for the industries. State-owned companies still today dominate Greenland. During the modernisation period, the idea that the Greenlandic should live on equal living standards as Danes was formed. This idea still dominates the relationship between Denmark and Greenland. (Paldam, 1994)

The Greenlandic population grew very fast during the 20th century as more Greenlandic got access to health care and modern housing. From being about 12,000 in 1900 the population grew to 57,000 in 2011 (Statistics Greenland, 2012). In the same year, about 89% of the population was born in Greenland, with people born in Denmark making up the biggest minority. 81% of the Greenlandic population live in cities, and 90% along the western coast of Greenland. (Statistics Greenland, 2011a)

2.2 Home Rule and Self-Rule

Greenland was granted home rule in 1979 following a referendum. Within the home rule agreement, several areas of responsibility were moved from Denmark to Greenland. This included e.g. health care and schools. When an area of responsibility was moved from Denmark to Greenland, a calculation was made of how much that particular area cost the Danish state, and a corresponding amount of money was transferred to the Greenlandic home rule government in the form of a block grant. (Karlsson, 2008) The logic was to keep the Greenlandic living and welfare standards on par with the Danish, while at the same time achieve increased political independence. The goal has since the introduction of the block grant been to top up the Greenlandic welfare until the Greenlandic economy is self-sustaining, at which point the grant will be abolished (Paldam, 1994).

Home rule was succeeded by self-rule, i.e. autonomy, in 2009 following a new referendum. This grants Greenland further powers vis-à-vis the Danish state. One result of this is that Greenland can choose for itself when to take over further areas of responsibility (Act on Greenlandic Self-Government, 2009). The most important areas that are still to be transferred from the Danish to the Greenlandic authorities are the police, the judicial system and prison and probation facilities. (Barfod, 2008)

Under the self-rule, the block grant that Greenland receives from the Danish state will no longer be raised when further areas of responsibility are transferred. Additionally, the block grant is frozen in real terms and will be adjusted by the Danish, not the Greenlandic, inflation. (Act on Greenland Self-Government, 2009) This is a political choice by Greenland in order to achieve increased independence (Abelsen, 2012, public meeting).

One of the first areas to be transferred to the Government of Greenland was the right to the mineral and hydrocarbon resources. This was transferred in 2010 and is now administered by the Greenlandic Bureau of Minerals and Petroleum (BMP)

(Ackrén et al., 2011). The Act on Greenland Self-Government (2009) states that the block grant will be reduced by half of any mineral resource revenue exceeding 75 million DKK. In the event that the block grant is reduced to zero, it will be discontinued and negotiations will take place to determine the future economic relations between Greenland and Denmark. These negotiations shall include how to divide future mineral and hydrocarbon resource income as well as how to handle the future of the block grant. (Act on Greenland Self-Government, 2009)

The Act on Greenland Self-Government (2009) also states that it is the people of Greenland that shall decide if Greenland should become independent from Denmark. If the Greenlandic people desire full independence, the Greenlandic and the Danish government will negotiate to render a proposal for independence. Both the Greenlandic parliament and a Greenlandic referendum will have to agree to the proposal and the Danish parliament will have to consent. (Act on Greenland Self-Government, 2009)

Greenlandic politics has since the introduction of the home rule been dominated by the social democratic party Siumut. From 1979 until 2009 Siumut governed Greenland through various coalitions. In 2009 the socialist party Inuit Ataqatigiit assumed office. The majority in the Greenlandic parliament has been left-leaning in every election since home rule was implemented. An overarching goal for Greenlandic politics has since 1979 been political independence (Poppel, 2012, interview).

2.3 The Greenlandic Economy

As mentioned, Denmark transfers a block grant to Greenland every year, in addition to financing areas of responsibility that are still the prerogative of the Danish state. This has a very large impact on the Greenlandic economy. Because of this block grant, the Greenlandic economy can have a much higher consumption than production. The block grant, including Danish state expenditure, as a part of the Greenlandic economy is shown in Figure 2.

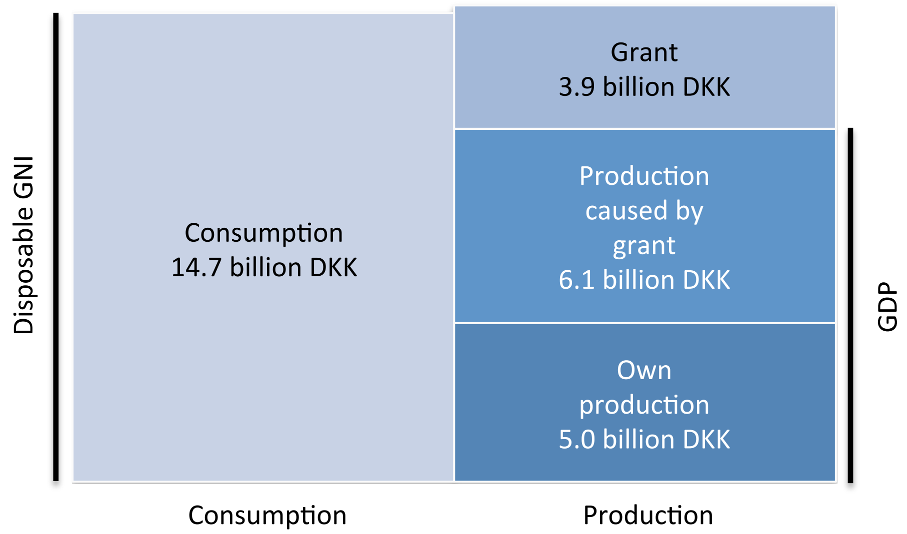

Figure 2. Greenlandic consumption (Disposable GNI), production (GDP) and the block grant including Danish state expenditure in billion DKK 2007.
Source: Own calculations based on Statistics Greenland (2012). Own production is an approximation of how high the GDP would be without the block grant. Production caused by grant is a result of the fiscal multiplier. Paldam (1994) estimates own production to 45% of GDP and we use this assumption. The difference between the columns consists of foreign transfers.

As can be seen in Figure 2, the consumption is about three times as high as the own production meaning that without the block grant, the living standard would fall by two thirds. This shows how dependent the Greenlandic economy is on the block grant.

In the 50s and 60s, there were almost no companies in Greenland. For the modernisation process to succeed in bringing Greenland from a fisher/hunter society to an industrialised country industrial companies were needed. Because of a lack of interest from private investors the state assumed responsibility. The fishing company Royal Greenland was founded as fishing was considered a promising industry for Greenland. This was possible because of large investments from the Danish state. The large investments were natural as Greenland now was an integrated region within Denmark, and because it was hoped that the investments would pay off later when the companies had become competitive and profitable. However, the companies have until today failed to create a private sector and are to a large extent still owned by the Government of Greenland. The result is that Greenland today has a very large public sector. Including state-owned companies, the government employs

86% of the population. This is shown in Figure 3. The large share of state-owned companies was, however, never intentional. (Dahl 1986; Paldam, 1994)

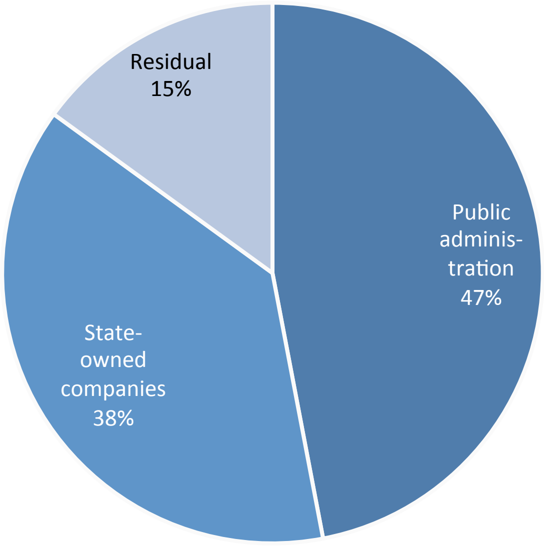

Figure 3. Employment by sector in 2009/2010.
Source: Own calculations based on Statistics Greenland (2012) and Karlsson (2009)

Fishing is still the most important industry in Greenland. Prawns is the largest fishing product and Greenland is the second largest prawn fishing nation in the world, after Canada (Karlsson, 2008). About 25% of the workforce is employed in the fishing cluster (Statistics Greenland, 2007). The number of fishermen is, however, relatively small, and most people employed in the fishing cluster are employed in a number of fishing-related industries, such as processing and wholesale. The fishing cluster in Greenland is mostly maintained through regulations and subsidies, and there is a substantial hidden unemployment in the sector (Karlsson, 2008; Andersen, 2012, e-mail correspondence).

The importance of the fishing industry is evident when looking at the Greenlandic exports in Figure 4. 54% of the Greenlandic export is prawns, with other fishing products making up another 34%. About 85% of all exports go to Denmark, but Greenlandic fishing products are often processed in Denmark and re-exported, mainly to Japan and the UK. (Statistics Greenland, 2011a; Karlsson, 2008) As the fish stock is limited in nature, it is not possible to sustainably grow the fishing volume indefinitely. Additionally, the price of prawns has been falling over the last couple of years (Department of Fisheries, Hunting and Agriculture, 2011).

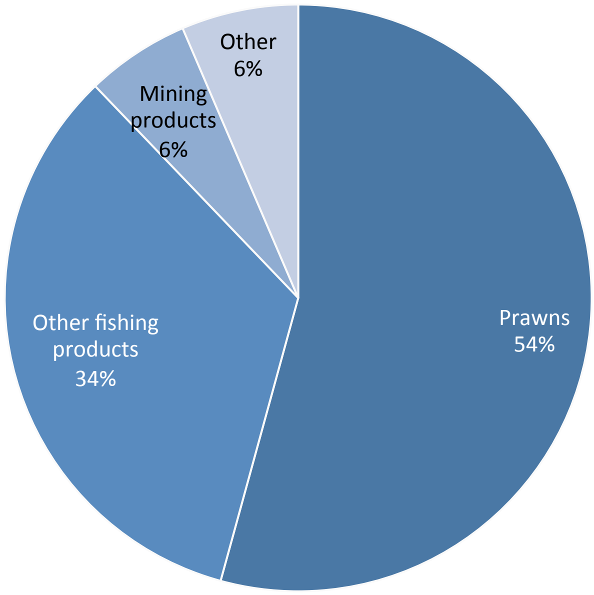

Figure 4. Greenlandic exports in 2009.
Source: Statistics Greenland (2011a)

2.4 Future Demographic Challenges

Both the Greenlandic Economic Council (2011) and the Tax and Welfare Commission (2011) point out that the current economic policies in Greenland are unsustainable for the next 20 - 30 years. This is primarily due to an ageing population, that will put pressure on the Greenlandic welfare system. This is a problem that Greenland shares with much of the industrialised world, but it has some specific characteristics in Greenland because of the special economic situation.

As the block grant is fixed in real terms, it decreases as a percentage of GDP as long as Greenland experiences real growth. This has led to a decrease in government income as a percentage of GDP since the 1990s. However, this decrease in income has been alleviated by a decrease in costs, thanks to a favourable demographic development since 2000. As can be seen in Figure 5, the dependency ratio has declined from 0,64 in 2001 to 0,60 in 2011, due to lower birth rates. Based on projections from Statistics Greenland, this favourable trend will continue until 2014. From there, the dependency ratio will start to rise again, due to a larger share of older people, and stabilise at around 0,7 in the early 2030s.

The conclusion of this is that Greenland has lived through the favourable demographic period, the demographic dividend, without actually reaping the benefits. Rather, the favourable demography has helped to conceal a problematic structural problem that will start to make itself known in the coming decades.

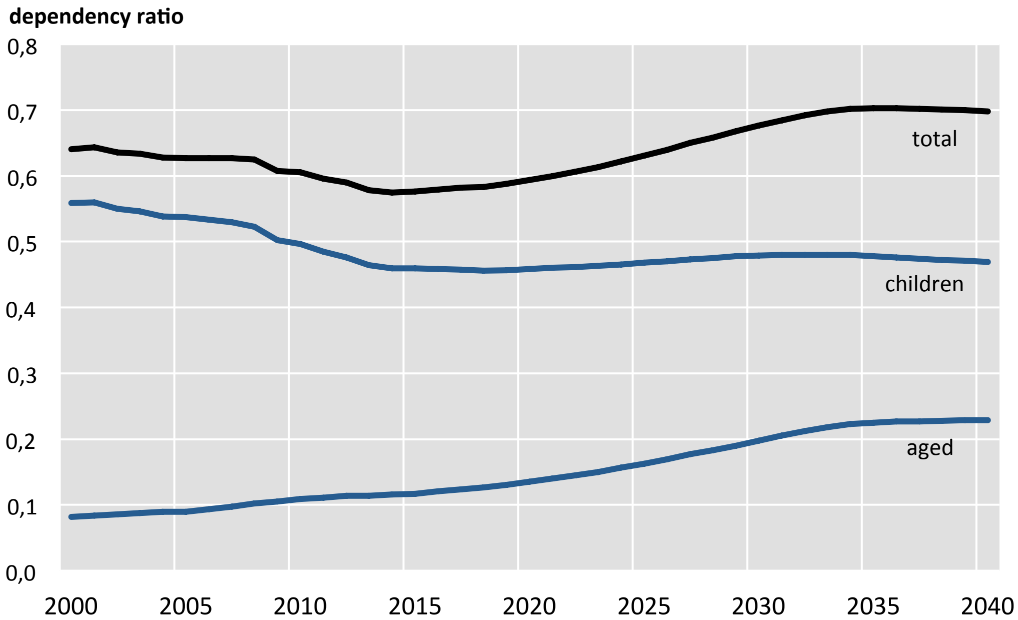

Figure 5. The historical and prognosticated dependency ratio in Greenland, i.e. how many children (age 0-19) and aged (age 65+) each person in the labour force (age 20-65) has to support.
Source: Statistics Greenland (2012)

2.5 Understanding the Focus on Hydrocarbon Resources

The previous sections review the Greenlandic history and economy. It is clear that Greenland is a small and relatively young democracy. During the 20th century, the country has passed through a fast development from fisher/hunter-society to a modern industrialised country. The transition has been made with help from Denmark. The block grant, which is the fundament of the government budget, was created in this process to top up Greenlandic consumption until the country is self-sustaining. As the block grant is frozen after the self-rule agreement, the future demographic challenges will not be financed by an increase in the transfers from Denmark. Greenland therefore needs to find a way to develop its economy.

The main industry in Greenland is fishing. This industry is, however, limited by the fish stocks and can therefore not grow indefinitely. Tourism and mineral extraction have been suggested to contribute the missing production. Mineral extraction has been present in Greenland since the 19th century, but has not yet contributed significantly to the Greenlandic economy as seen in Figure 4. Paldam (1994) estimates that mines corresponding to 120 times the well-known Marmorilik mine would be necessary to replace the block grant. As such, mining alone is probably not going to make Greenland self-sustaining. Tourism is also a focus area in Greenland, but has according to Løgstrup (2012, interview) not yet lived up to the expectations and only constitutes a small fraction of the economy.

Hydrocarbon resources might be especially interesting in Greenland because of this perceived lack of alternatives. The focus on mineral resources was, e.g., evident on a public meeting with the Government of Greenland in Sisimiut in March 2012, with Greenlandic premier Kuupik Kleist, minister for finances Maliina Abelsen and minister for industry and mineral resources Ove Karl Berthelsen (2012, public meeting).

3 Geological Conditions

To build an oil industry a range of conditions need to be fulfilled. Naturally, there has to be recoverable oil in sufficient quantities. In order to quantify the recoverable resources, both geology and other factors such as the location and climate need to be taken into account.

This chapter goes through the geological background and explains why Greenland is interesting for oil exploration. Firstly, hydrocarbon geology is introduced to provide a scientific understanding for how oil is created. Hydrocarbon exploration is then discussed, with a special focus on the exploration process in Greenland. This is followed by a presentation of the challenges facing oil production in Greenland and a description of the technology proposed to overcome them. Finally, an estimation of technically recoverable hydrocarbon resources is performed and presented.

3.1 Hydrocarbon Geology

Oil and natural gas are hydrocarbons, which are produced in a slow geological process from organic material. The process starts with sedimentation of organic material at the bottom of a lake or ocean under anoxic, oxygen free, conditions. When no oxygen is present the organic material will go through a different decomposition process than with oxygen. This is done by sulphur reducing bacteria. The decomposition ends with the forming of heavy geopolymers, which are collectively known as kerogen. Kerogen is, basically, a heavy, black, tar-like substance that can be found naturally, e.g., at the bottom of the Black Sea or in other oxygen scarce environments. (Hunt, 1995)

As sedimentation continues, more and more matter is stacked on top of the kerogen. The pressure that builds up increases the temperature of the matter. The further down it is pushed, the higher the pressure and temperature. When the temperature reaches 60 °C, the long polymer chains of the kerogen start to crack into smaller hydrocarbons. These hydrocarbons are known as oil. The higher the temperature, the smaller the parts that the kerogen cracks into, and the lighter the oil. Oil is formed within the temperature span of approximately 60-160 °C. This span is called the oil window. (Hunt, 1995)

When the hydrocarbons crack further, gases start to form instead of liquid oil. These are mainly natural gas, or methane, but also other gases such as propane and butane. This process occurs between 100-200 °C in what is called the gas window. Gas can be formed both from kerogen and from oil. Between half and two-thirds of the natural gas in the world has been formed from cracked oil. (Hunt, 1995)

The sedimentation not only forms hydrocarbons, but also a sedimentary rock around them. The rock where the hydrocarbon formation has occurred is called a source rock. In the search for hydrocarbons, locating possible source rocks is therefore a priority. However, it is not certain that the hydrocarbons stay in the source rock. Over geological time frames, it is possible that the oil and gas migrates from the rock where it is formed and ends up in another rock, a reservoir. As the hydrocarbons are lighter than water, they will tend to migrate up through the underground. A typical reservoir therefore has a high quality seal on top that stops the migration. These reservoir rocks are therefore also interesting to search for. If the hydrocarbons have not escaped some time during geological history, the reservoir might still hold hydrocarbons that are possible to extract. Together, the reservoir rock, the migration pathways and the source rock are called a petroleum system. (Hunt 1995) Exploration activity is focused on locating these petroleum systems, and drilling into the reservoirs to find oil. The process for offshore hydrocarbon exploration is described in the next section.

3.2 Offshore Hydrocarbon Exploration

The process from exploring through developing to decommissioning of an oil field can be divided into a number of stages. Licences are assigned to companies and give the right to explore the designated area. If findings are made, the licence gives the company the right to develop a production site under specific terms outlined in the licence. A more detailed description of the first steps is presented below followed by a description of how this is done in Greenland.

3.2.1 Legal Framework

The UN Convention on the Law of the Sea (UNCLOS) from 1982 is the framework for marine natural resources. The UNCLOS states that a country has exclusive right to its continental shelf and the 200 nautical mile exclusive economic zone (EEZ). (Bret-Rouzaut & Favennec, 2011) The current licences in the Greenlandic waters are within the exclusive economic zone of Greenland as shown in Figure 6.

The Greenlandic Act on Mineral Resources (2009) states that the Government of Greenland has the property right to rule over and exploit the mineral resources in the underground in Greenland. This means that the Government of Greenland can decide how and when hydrocarbon activities should be performed.

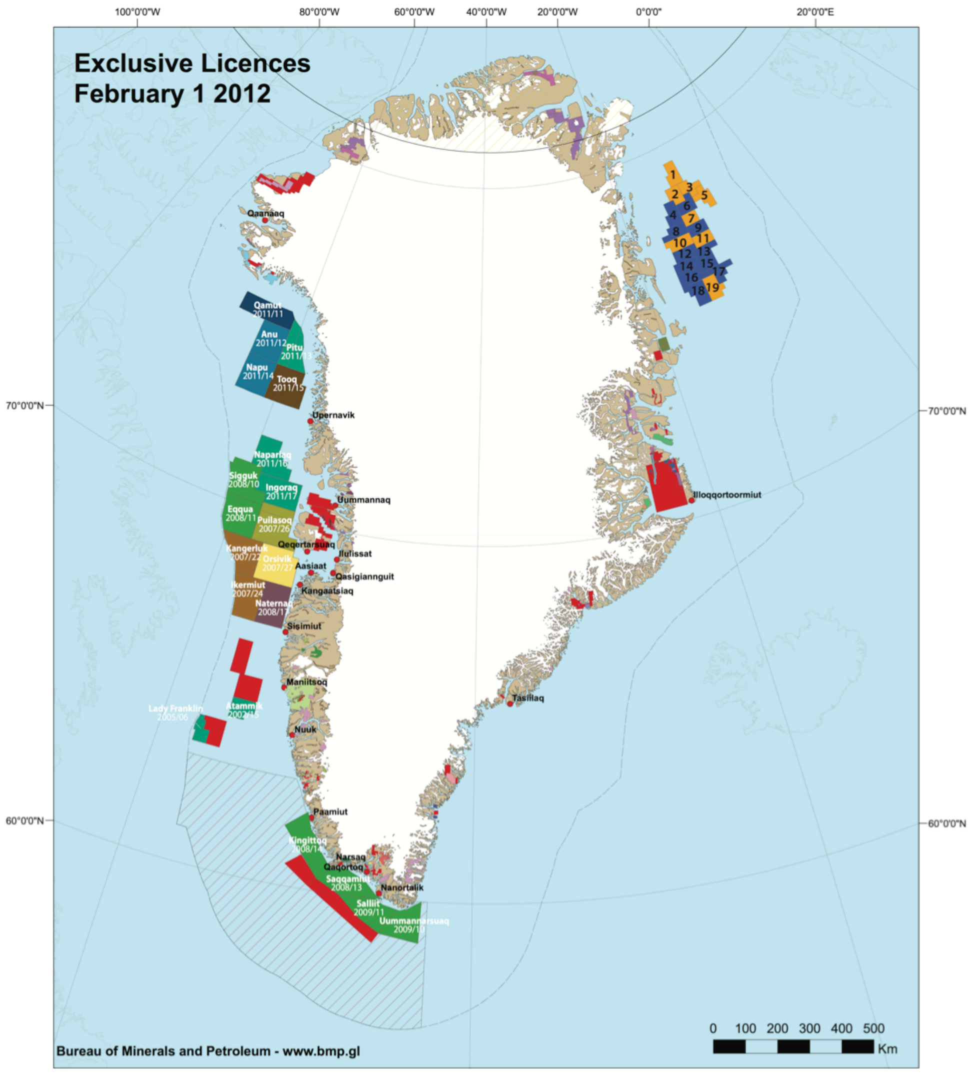

Figure 6. Overview map of the exclusive economic zone of Greenland and the hydrocarbon licences.
Source: BMP (2012a)

3.2.2 The Exploration Process

The exploration process starts with that the territorial owner, usually the government, divides the area into sub-areas, or licensing blocks. Companies are then invited to apply for the right to explore in that block. Licences can be awarded based on the commitments offered in the application or through auctions. Companies that are awarded licences commit themselves to gather seismic data in the area in order to establish the possibilities for hydrocarbon findings. The aim is to locate possible source rocks, reservoirs and migration pathways, i.e. a working petroleum system.

Generally, the territorial owner will keep the right to a copy of the data. (Bjelm, 2012, interview)

A prospect description, i.e. an interpretation of the seismic data, then forms the basis for an application for drilling in the area. The seismic data is used to calculate the most likely reservoirs. If permission is granted, the potential reservoirs are tested by drilling into them. The licence holder generally wears the cost of drilling, but the results are shared between the licence holder and the territorial owner. (Bjelm, 2012, interview) According to Kai Sørensen, ex director at GEUS with experience from the oil industry (2012, interview), a rule of thumb is that it is more expensive to drill offshore than onshore, while the opposite is true for seismic data gathering. Offshore drillings are therefore usually preceded by a longer period of seismic data gathering than onshore drillings.

In case hydrocarbons are encountered, the size of the encountered reservoir is estimated. The profitability of production is evaluated, and if it is deemed profitable, the project moves into the development stage. (Bjelm, 2012, interview)

3.2.3 Greenlandic Exploration History

The current hydrocarbon interest in Greenland is not unique in history. On the contrary, Greenland has been the focus of much attention from oil companies over the years, and today is the third time since the 1970s that speculation about future oil discoveries is widespread.

The first time Greenland was in focus for its oil potential was in the 1970s, after the oil crisis, when the Danish government searched for ways to reduce its dependence on oil imports. (Krogh Andersen, 2008) Licences were granted to six different oil companies including Chevron, Total, BP and Mobil. The oil companies gathered seismic data for a couple of years, and in 1976-77 five exploration wells were drilled in West Greenland. (Christiansen, 2011) The results were disappointing as they indicated that the source rocks in the area were only gas-prone, a general opinion that was not revised until the 1990s. (GEUS, 2002) These drillings can be seen in Figure 7.

In the beginning of the 1990s, the Danish government funded new seismic data gathering that increased interest once more. Oil seeps were found onshore in the Nuussuaq area. This oil, which can be viewed in test tubes at the GEUS headquarters in Copenhagen, bears similarities with oil found in the Sverdrup basin in the north of Canada and indicates that there is indeed a petroleum system in place in Greenland. Source rocks have been documented, even if some of the oil comes from a source rock that is not yet sampled. (GEUS, 2002) Initially the oil price was low and interest from industry therefore weak. As new information emerged, interest rose and in 1996 a new licensing round was held. The second oil hype culminated with Statoil drilling the Qulleq-1 well in 2000. Also this time, however, the well was found dry. Additionally, an attempt at onshore exploration was made in the 1990s, on the island Nuussuaq. A drilling operation was conducted on the island by the small Canadian company grønArctic, but the results were once again negative. (Christensen, 2011) These drillings can also be seen in Figure 7.

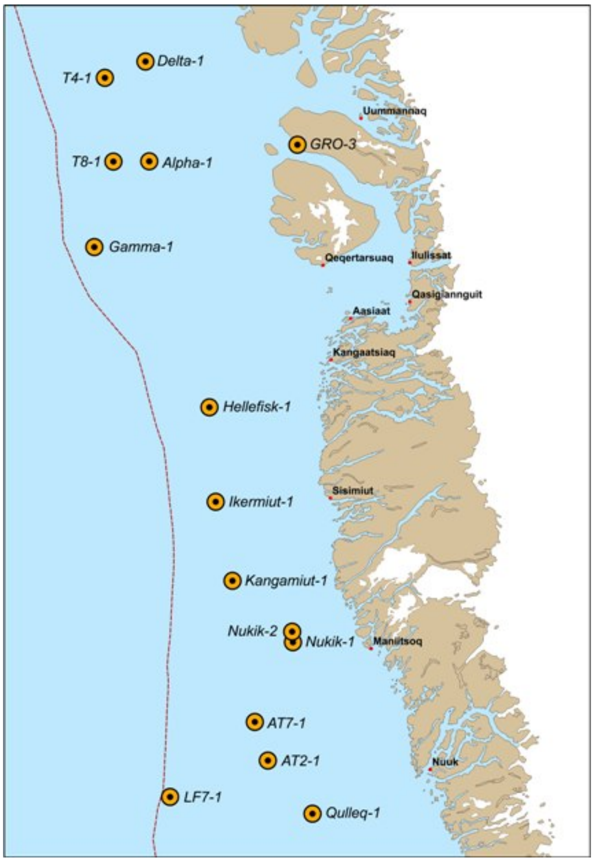

Figure 7. Drillings performed in Greenland from the 1970s until today. Source: BMP (2012b)

3.2.4 Greenlandic Exploration Today

In the 2000s, the United States Geological Survey (USGS) released a series of reports on the resource potential in the Arctic as part of the Circum-Arctic Oil and Gas Resource Appraisal. The results were promising, and showed that 13% of the mean estimated global undiscovered oil, and 30% of the global undiscovered conventional gas can be found north of the Arctic Circle (Gautier et al., 2011). This started the third and current oil hype in Greenland.

The licensing rounds so far have been focused on the west coast of Greenland. Licensing rounds were held in 2002, and further rounds in 2004, 2006, 2007, 2008 and 2010. There are also some licences granted in an open-door licencing area offshore southern Greenland. There has been a great interest in taking part in the licensing rounds, and many of the world's largest oil companies, such as Chevron, Exxon, Shell, Maersk, Petronas and Cairn Energy, are currently holding licences offshore West Greenland. Licensing rounds for the northeastern coast will follow in 2012 and 2013 (BMP, 2011).

The current licences have been awarded to the applying companies by the Government of Greenland. The applying companies have paid a minor application fee and a licence fee, and accepted to give 12,5% ownership in each licence to the Greenlandic state through the state oil company, Nunaoil. The licences have a duration of 10 years for West Greenland and 16 years for East Greenland. They can be extended to 30 years if production is intended. If a company starts production, it will have to compensate the Government of Greenland through a royalty system. We return to the royalty system in section 4.1.5. (BMP, 2004a, 2006a, 2007a 2009a)

Cairn Energy, which operates in Greenland under its subsidiary Capricorn Greenland Exploration, is the only company to have drilled since 2000. The company has in 2010 and 2011 drilled 8 wells, as seen in Figure 7. The total cost has been 5 billion DKK. This makes the current oil exploration programme the largest so far. While Cairn states that the prerequisites for success are present, any commercially or technically recoverable deposits have so far not been made. (Berlingske Business, 2012) Cairn has decided to put further drillings on hold for 2012, and sold part of its Greenland stake to the Norwegian oil giant Statoil in early 2012. (Financial Times, 2012)

The Bureau of Minerals and Petroleum states that there is a relatively high level of exploration activity in Greenland at the moment. In the period 2013-2016 there will be exploration drillings in the Disko West area and seismic data collection. (Bogø Wilms, 2012, interview). Cairn has in this respect worked rather unconventionally, and made drillings earlier with less seismic data behind. The result is that the drillings become less accurate. This could explain the fact that Cairn's drillings have not yet resulted in any commercial findings according to Mette Katrine Runge (2012, interview), geologist at the Greenlandic state oil company Nunaoil.

According to Sørensen (2012, interview), an ex director at GEUS with experience from the oil industry, oil exploration is often driven by high oil prices. When oil prices are high, oil companies accumulate capital. One effect of this is that they initiate large-scale exploration projects. (Sørensen, 2012, interview) Therefore, the high interest in oil exploration at the moment might reflect the elevated oil prices rather than proven facts about oil resources. If so, it is likely that a fall in the oil price can affect the activity in Greenland negatively. Figure 8 shows the real oil price and the number of drillings per year in Greenland.

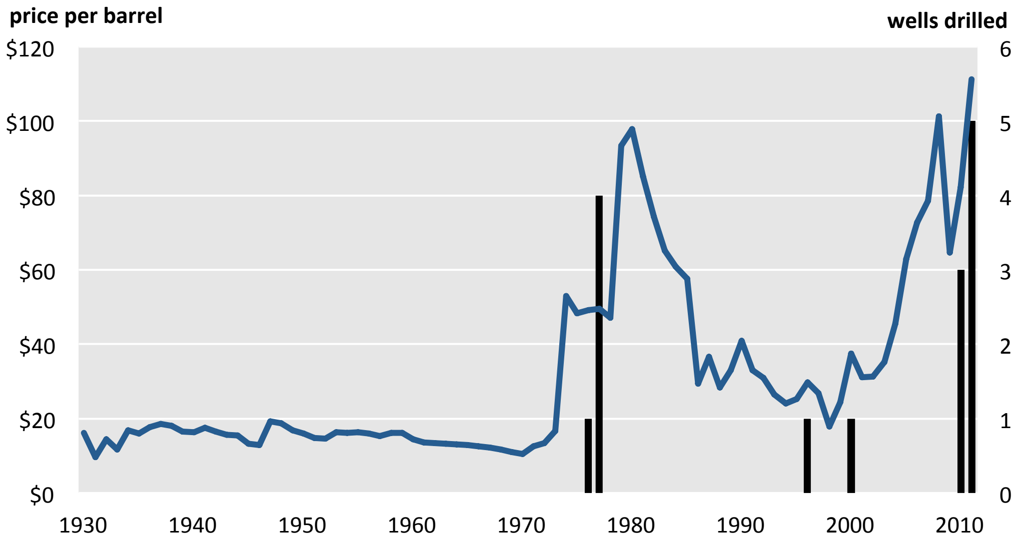

Figure 8. Real oil prices in dollars per barrel (left axis) and number of drillings in Greenland (right axis).
Source: EIA (2012a), EIA (2012b), BLS (2012) and BMP (2012b)

3.3 Is Production in Greenland Feasible?

If oil is encountered in Greenland, this will be one of the most challenging areas for oil production so far. Will it be possible to produce oil under these circumstances at all, and to what cost? This section goes through the challenges that the oil industry will face in Greenland and provides input for the discussion on economic viability of oil production that follows in chapter 4.

The climate conditions in Greenland are a major challenge for oil activities. The southwestern part of Greenland is located south of the Arctic Circle. The climate in this region is relatively mild and the sea is often open all year round. The further north along the west coast, however, the more severe the climate. The northernmost all year ice-free harbour on the west coast is Sisimiut, located just north of the Arctic Circle. In winter, the sea is generally frozen north of Sisimiut, where the majority of the West Greenland licensing blocks are located. This implies that the cost of production in West Greenland will be high. Hans Hinrichsen, General Manager at the Greenland School of Minerals and Petroleum (2012, interview) points out that production in the Canadian Arctic has been possible, and that the conditions in West Greenland are similar to the conditions there.

The north and east coast of Greenland are characterised by an extremely harsh climate. Kai Sørensen (2012, interview), an ex director at GEUS with experience from the oil industry, states that Danmarkshavn on the east coast of Greenland is e.g. often only accessible from the sea around one month of the year. Sørensen et al.

(2011) note that the north of Greenland probably suffers the most adverse ice conditions in the entire Arctic. Sørensen (2012, interview) is sceptical to production in the northeast with present climate and technology.

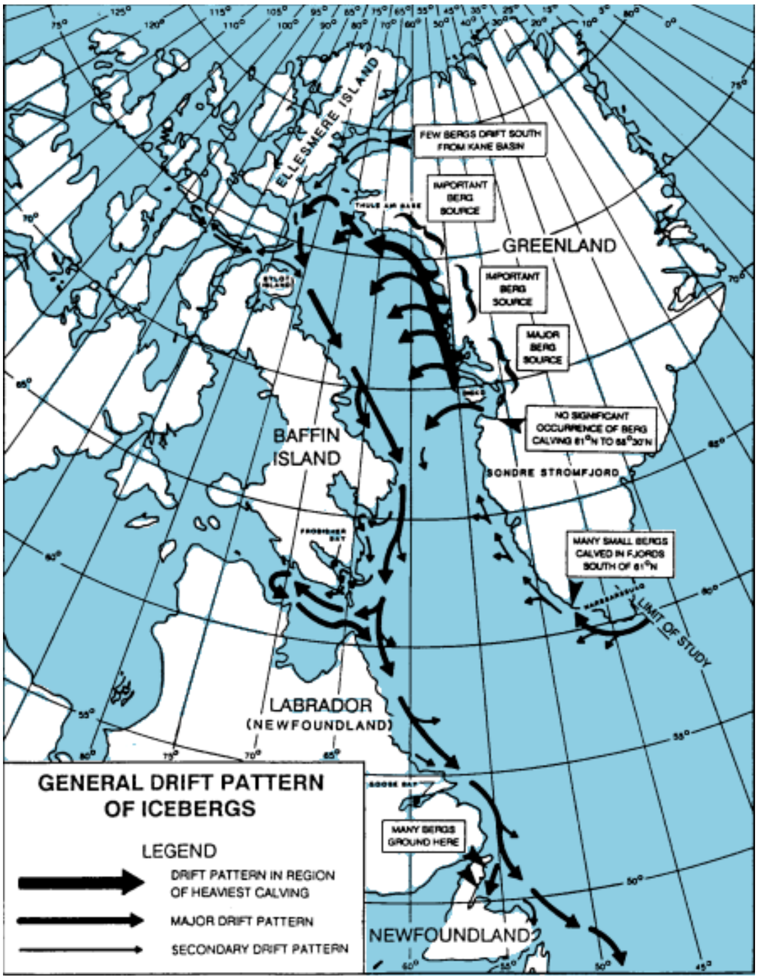

Figure 9. General Drift Pattern of Icebergs on the Greenlandic West Coast. Source: GEUS (2001)

In the northwest and east of Greenland icebergs are a common feature in the summer. The general drift patterns of icebergs on the west coast can be viewed in Figure 9. Ice loads from floating ice floes have been calculated from experiments in the northwest of Greenland to reach 40.000 tonnes on a 70 m wide structure. This gives some indication of the tremendous force exerted by the ice masses in the Arctic region. (Paulin, 2008) The ice conditions imply that the production technology needs to withstand the pressure, be mobile or operate on the sea floor. This will also increase the cost relative to conventional oil production.

While the challenges listed above are considerable, it is important to understand that the oil industry has a history of overcoming production challenges.

In the 1970s, all offshore hydrocarbons at depths greater than 200 metres were considered non-conventional and unprofitable. Today, it is possible to produce at depths of 2,000 metres. The boundary between the recoverable and the non-recoverable has been pushed over time. (Bret-Rouzaut & Favennec, 2011) The Norwegian oil experience highlights how the oil industry has managed to exploit areas that were once considered too challenging. The technological advances have not come easily, however, as is described in case 1.

There are no signs that this technological development within the oil industry is about to stop. The fact that oil companies invest in oil exploration in Greenland is a good indicator of the optimism surrounding technological development. Mette Katrine Runge (2012, interview), geologist at the Greenlandic state oil company Nunaoil, agrees and states that there are proposals for production solutions, even if they are not yet official.

We therefore conclude that production in Greenland will be possible, even though the conditions today are regarded as challenging.

Case 1. Technology Learning Curve

As the technological frontier has been pushed there have always been problems before the new conditions have been mastered. Looking back, the Norwegian oil adventure is incredibly successful. Initially, however, there were many challenges to overcome. When the Norwegian oil era started both technology and rules were taken from earlier projects by American oil firms on the coast of the American south. Conditions in the North Sea were more challenging, however. Between 1965 and 1978, 82 workers died in connection with oil activities in Norway. In 1977 a blow out occurred in the Ekofisk oil field. In 1980, a semi-submersible rig in the Ekofisk field collapsed and 123 people lost their lives. (Ryggvik, 2010) The experience from Norway suggests that the oil industry will eventually overcome the challenges, but also that there will be a costly learning period before the new processes are well-functioning.

3.4 Estimating Technically Recoverable Resources

The previous section reviews how far the exploration process has come today in Greenland, and describes the challenges that the oil industry will face. The conclusion from the discussion above is that oil production will be challenging but possible. In this section, we take the estimations of the recoverable resources in

Greenland and make our own analysis to assess how much oil is likely to be found. This quantifies the geological potential and provides an answer to how favourable the geological conditions are to achieve a self-sustaining economy in Greenland based on hydrocarbons.

The data used comes from the USGS, that between 2000-2008 made an assessment of the undiscovered oil in the Arctic. The assessments of the West Greenland/East Canada and East Greenland provinces finished in 2008 and 2007 respectively. The USGS is a bureau within the US Department of the Interior, has around 10,000 employees and its mission is to "serve the Nation by providing reliable scientific information to describe and understand the Earth" (USGS, 2012). Their assessment method is a statistical model with geological data input. Their model is based on experience and has been continuously updated since the 1970s. (Charpentier & Klett, 2005) The USGS assessments are the most recent publicly available assessments of the Greenlandic offshore areas and have incorporated current geological knowledge, including input from the Geological Survey of Denmark and Greenland (GEUS). We therefore consider the USGS data reliable.

Hydrocarbon resources can be measured in many ways. We use three different levels of measuring hydrocarbon resources:

1. In-place resources
2. Technically recoverable resources
3. Economically recoverable resources

The first measure describes all resources that exist in a given area. Since resource accumulations can vary much in size and location, this measure is not very helpful from a recoverability point of view. (Sørensen, 2012, interview) The second measure describes the size of the in-place resources that can be recovered with the technology of today. Included is also an expected technological development that results in so-called reserve growth as a larger share of the reserve can be expected to be recovered in the future. The third measure takes costs and oil prices into account as well and shows how much of the hydrocarbons that will be commercially viable to exploit. While the first measure can be objectively estimated, the other two measures are dependent on technology and macroeconomic factors. (Bret-Rouzaut & Favennec, 2011) The USGS assessments measure the second level, i.e. technically recoverable resources including reserve growth.

3.4.1 Oil vs. Gas Resources

The USGS assesses that both oil and gas can be found offshore Greenland. Gas has different characteristics than oil and to export it from Greenland would require either a gas pipeline or that it is compressed into liquefied natural gas and transported by tankers. Gas production is therefore deemed uneconomical by ex director at GEUS Kai Sørensen (2012, interview), geologist at Nunaoil Mette Katrine Runge (2012, interview), head of section oil at the Bureau of Minerals and Petroleum Lonnie Bogø Wilms (2012, interview) and consultant Richard Shepherd (2012, e-mail correspondence). In Canada, the large gas reserves found have not been exploited so far (Runge, 2012, interview). In addition, there is a large supply of gas currently available in both Northern America and Russia, where the necessary infrastructure is already in place (Sørensen, 2012, interview; Shepherd, 2012, e-mail correspondence). Based on this information, this thesis only takes the potential oil findings into account.

3.4.2 Geological Input Data

Because of the uncertainty involved in resource assessments, estimates are never presented as just one value. Instead, an outcome distribution is generally given. For simplicity, the results are usually presented as the 5th, 50th and 95th percentile or P5, P50 and P95 for short. A P5 value e.g. means that there is a 5% chance of finding this value or more. In addition to this, a mean value can be provided. Because the distribution is skewed, the mean value is higher than the P50 value when uncertainty is high. (Bret-Rouzaut & Favennec, 2011)

Figure 10. Assessment units in West Greenland and East Canada.
Source: Schenk et al. (2008)

In the USGS assessments, the areas are divided into a number of assessment units. P5, P50, P95 and mean values are presented for each assessment unit. The values are a result of a geological assessment model called the seventh approximation. (Charpentier & Klett, 2005). The estimated amounts only include oil that is technically recoverable under standard climate conditions, and does not adjust for the economic viability under Arctic conditions (Sørensen, 2012, interview).

Table 1 shows the USGS assessment. Figure 10 shows the assessment units in west Greenland. For reference, the current licence blocks are shown in Figure 6 earlier.

Table 1. Estimated hydrocarbon resources in the Greenland area.
Source: Gautier (2007), Schenk et al. (2008), Schenk (2010) and Gautier (2012, e-mail correspondence). SD is the standard deviation of the mean value.

Assessment Unit (AU)	Million barrels of oil				
	P5	P50	P95	Mean	SD
West Greenland/East Canada					
AU1 Eurekan Structures	6,626	0	0	1,133	2,650
AU2 Northwest Greenland Rifted Margin	19,465	464	0	4,903	7,280
AU3 Northeast Canada Rifted Margin	5,847	0	0	1,431	2,198
AU4 Baffin Bay Basin	8,470	0	0	1,555	3,232
AU5 Greater Ungava Fault Zone	8,514	0	0	1,675	3,233
East Greenland					
AU1 North Danmarkshavn Salt Basin	11,793	1,989	0	3,274	4,237
AU2 South Danmarkshavn Basin	13,996	3,228	0	4,384	4,822
AU3 Northeast Greenland Volcanic Province	2,757	0	0	497	1,024
AU4 Thetis Basin	2,095	0	0	537	776
AU5 Liverpool Land Basin	1,122	0	0	209	453

3.4.3 Simulation

In order to estimate the oil reserves that Greenland can expect to find, we need to aggregate the estimates for the Greenlandic assessment units. This is not as easy as it sounds. The problem can be illustrated with a game of dice. We know that each die has six possible outcomes that are all equally probable. The expected, or mean, value of each die is 3.5 and the probability of rolling a six is one in six. If we roll two dice, the expected value will be doubled to 7. However, the probability of scoring two sixes is not one in six but rather one in 36. In the same way, the mean values from a hydrocarbon assessment can be added together and presented as average expected findings but the P5, P50 and P95 values cannot. Hydrocarbon distribution outcomes are even more complicated. Firstly, the die is round, i.e. there are no discrete steps. Secondly, the die is not evenly weighted, i.e. some outcomes are more likely than others.

If we roll one such special round die for each assessment unit simultaneously a large number of times, we get an aggregated outcome. This is the principle behind a Monte Carlo simulation. We construct such a Monte Carlo simulation to aggregate the USGS data. In this simulation, we include relevant assessment units, i.e. those that are within the Greenlandic territorial waters and have current active licences or upcoming licensing rounds. These include roughly 80% of the total mean values in Table 1. We simulate a total of 1000 scenarios. The details of the assessment unit selection and simulation are found in appendix 1.

Figure 11 presents the results of the simulation. The y-axis shows billion barrels of oil and the x-axis shows the probability of finding a certain amount or more. As such, the figure shows the percentage probability of finding at least a certain amount of oil. E.g., it is possible to read from the figure that there is a 25% probability that 20,000 million barrels of oil or more will be found.

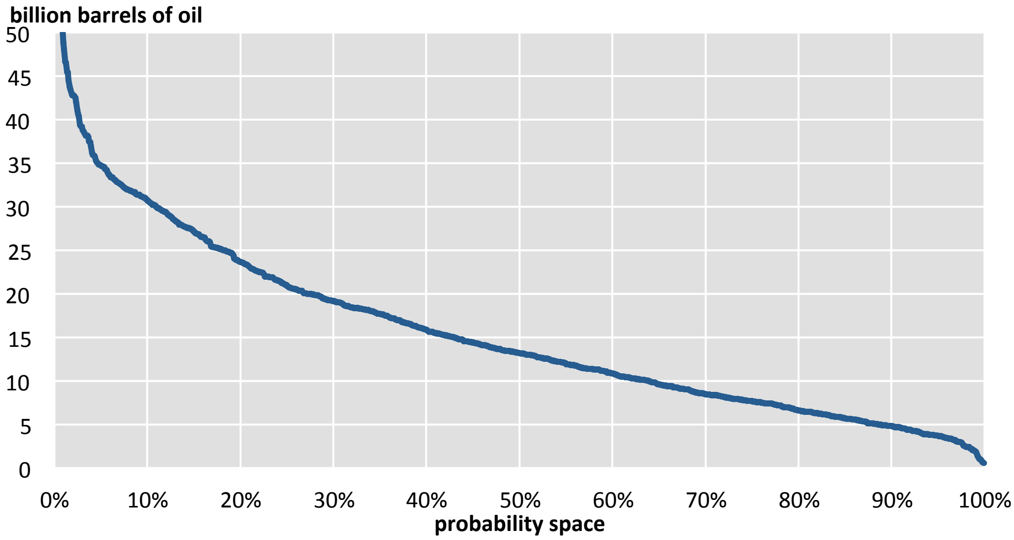

Figure 11. Aggregated technically recoverable resources in West and East Greenland. Source: Own calculations based on Gautier (2007), Schenk et al. (2008), Schenk (2012) and Gautier (2012, e-mail correspondence)

The geological data, while it is the best available, is still a theoretical model and may be wrong. There is also a large variance in the outcome, where the 5th percentile is more than 9 times the 95th percentile meaning that it is hard to know what to expect. The results should therefore be interpreted with caution. The uncertainty depends in this case primarily on the geological data. The uncertainty introduced by our simulation is small in comparison.

3.4.4 Interpretation

The 5^{th}, 50^{th} and 95^{th} percentile of the total technically recoverable resources, as seen in Figure 11, are presented in Table 2. In order to provide a frame of references we will compare them to the ultimate oil reserves in Norway and the world. The ultimate oil reserves are the sum of the produced, discovered and estimated undiscovered resources, and make it possible to compare with a hypothetically unexplored Norway and world. The findings are also compared to the world consumption, which is 87 million barrels of oil/day (BP, 2011).

Table 2. Greenlandic resources compared to Norway and the world.
Source: Own calculations based on Gautier (2007), Schenk et al. (2008), Schenk (2010), Gautier (2012, e-mail correspondence), Government of Norway (2012b), Bret-Rouzaut & Favennec (2011), and BP (2011). The ultimate oil reserves in Norway are 45,300 million barrels of oil (Government of Norway, 2012b). The ultimate oil reserves in the world are estimated to 3,000 billion barrels (Bret-Rouzaut & Favennec, 2011).

	5th percentile	**50th percentile**	**95th percentile**
Greenland's total technically recoverable resources in million barrels of oil	34,695	13,189	3,699
% of Norway's resources	77%	29%	8%
% of world resources	1.2%	0.4%	0.1%
Months of world consumption	13.1 months	5.0 months	1.4 months

Looking only at the technically recoverable resources, the numbers are significant considering that the Greenlandic population is around 1% of the Norwegian. However, when compared to world consumption, it is evident that the Greenlandic oil resources are modest in a global context. There will as such not be a dramatic change in the world oil market if Greenland finds oil.

3.5 Geological Conclusions

In this chapter, we analyse the geological conditions for building a self-sustaining economy in Greenland based on hydrocarbons. The first thing we note is that Greenland has been interesting for oil exploration before. Oil exploration activity has been particularly high when the oil prices have been high. The current oil exploration program is the biggest so far and it coincides both with high oil prices and that the information about the Greenlandic underground is more precise and encouraging than before. Source rocks have been found and the USGS predicts that there is a large oil potential in Greenland.

In this chapter, we aggregate the USGS data through a simulation and make predictions for how much oil there is in Greenland. Through this, we find support for the optimism surrounding the geological conditions. According to our results, it is very likely that oil will be found offshore Greenland. The results show e.g. that Greenland has a 50% probability of finding at least 29% of Norway's ultimately recoverable resources and a 95% probability of finding at least 8%. This is a significant amount considering the size of the Greenlandic population.

We therefore conclude that there are favourable geological conditions to make Greenland self-sustaining. The results do, however, not take the climate conditions into account. The climate will have an impact on the costs and the time frames of production. This affects the economic conditions for making Greenland self-sustaining. Chapter 4 discusses this.

4 Economic Conditions

We conclude in the last chapter that the geological conditions are favourable to make Greenland self-sustaining. In order to determine the potential direct economic benefit of the oil resources for Greenland, however, the technical estimates from chapter 3 need to be converted to money. This task is complicated by that it requires input of a range of macroeconomic variables. Additionally, it is dependent on the legal framework for oil production and how the income will be shared between the oil companies and the state. Nevertheless, in this chapter, we make an estimate so that Greenland can have a realistic view of what to expect.

To do this, we construct a model that calculates the net present value of potential direct government oil income. Since only a few variables are given, we estimate some of the other parameters. For the estimates, we use the methodology illustrated in Figure 1. We present four scenarios for a self-sustaining Greenlandic economy and assess the probabilities for them based on the potential direct government oil income.

Before we draw any conclusions on how this money could be used, we need to discuss the problematic aspects of large external incomes, namely the Dutch disease and income volatility. We show that Greenland already suffers from the Dutch disease and present some suggestions for how the disease can be managed.

4.1 Modelling Direct Government Oil Income

The state income is in the Greenlandic case given by the government share of the profit from oil production. Chapter 3 estimates the amount of technically recoverable oil. However, not all of this will be profitable to recover. For our model, we therefore use a recoverability modifier to estimate the amount of economically recoverable oil. The profit from oil production is determined by the amount of oil that is produced times the profit per barrel (oil price – production cost). This profit will be shared between the oil companies and the state. The state share is called the government take and is determined by the contracts between the companies and the state.

The direct government oil income can thus be calculated as:

$$y = R * m * (p - c) * x * t$$

where,

- y is the direct government oil income in DKK
- R is the technically recoverable resources found (from chapter 3), expressed as million barrels of oil

- m is the economic recoverability modifier, expressed as a percentage
- p is the oil price in USD
- c is the average cost of producing the oil in USD
- x is the real exchange rate DKK/USD
- t is the government take, i.e. how much of the profit that the state takes in fees, royalties and taxes, expressed as a percentage

The calculation presented above does not take the time value of the income into account. To incorporate this, the starting year of production and the length of the production have to be estimated. Since these could be different for West and East Greenland, they have to be calculated separately. The model is thus the sum of the net present values of an annuity income from the production for West and East Greenland, or, more formally:

$$y = \sum_{n=n_{first-year}^{west}}^{n_{last-year}^{west}} \frac{R_n^{west} * m * (p-c) * x * t}{(1+i)^{n-n_{today}}} + \sum_{n=n_{first-year}^{east}}^{n_{last-year}^{east}} \frac{R_n^{east} * m * (p-c) * x * t}{(1+i)^{n-n_{today}}}$$

where, in addition to the parameters listed above,

- y is the value of the direct government oil income in DKK at n_{today}
- R_n is the resources found in year n, expressed as million barrels of oil
- n is the year
- n_{today} is the end of 2011
- $n_{first-year}$ is the year of production start
- $n_{last-year}$ is the year of production end
- i is the real discount rate

In our model we use real prices at year-end 2011 and therefore real interest and exchange rates. The result, y, is the net present value of the potential direct government oil income which we use for comparisons. All of the parameters listed are discussed in detail in the following and the methodology described in Figure 1 is applied.

4.1.1 How much oil can be recovered? (m)

All technically recoverable resource will not be extracted due to the special challenges that the oil industry will face in Greenland, as presented in chapter 3. Therefore the share that will actually be produced needs to be determined. Shepherd (2012, e-mail correspondence), at the hydrocarbon consulting firm Petrologica, estimates the technical recoverability to 70% of in-place resources and economical recoverability to 20% of the in-place resources for the Arctic. This can be compared to a standard economic recoverability of 30-40% (Bret-Rouzaut & Favennec, 2011). Considering the challenges in Greenland, 20% is a reasonable assumption.

This means that the technically recoverable resources from chapter 3 correspond to 70% of the total amount. Therefore, the technically recoverable resources are modified by 20% out of 70%. The recoverability modifier, m, is 20%/70% ≈ 29%, meaning that only about 29% of the resources calculated in chapter 3 are exploitable today.

4.1.2 How high is the oil price? (p)

In the model, the oil price is one of the most important parameters. As figure X shows, oil prices have from 1970 and forward behaved more or less stochastically, without any discernible trend. Bret-Rouzaut & Favennec (2011) state that it is likely that the prices will remain volatile in the long term. However, it is at the same time unlikely that the prices will fall back to the low levels of the 1990s (Bret-Rouzaut & Favennec, 2011). In many countries, oil exports is a fundament of the government budget, particularly in the Middle East. These countries rely on that the prices stay above $80 per barrel. This has a large impact on the development of the prices, as there are strong political motives to keep the prices up. (IEA, 2011) The uncertainty surrounding long-term oil prices has a significant impact on the outlook for an oil-based economy in Greenland.

Since the oil price is the single largest uncertainty factor in the simulation, we use a spectrum of four different oil prices in the model. Since extraction costs are estimated to $50 per barrel, oil prices of $50 per barrel and below are unprofitable. We therefore use the following real oil prices: $75, $100, $150 and $200 per barrel. We assume that these cover a sufficiently large span in the oil price to accommodate the future uncertainty and the predictions presented above.

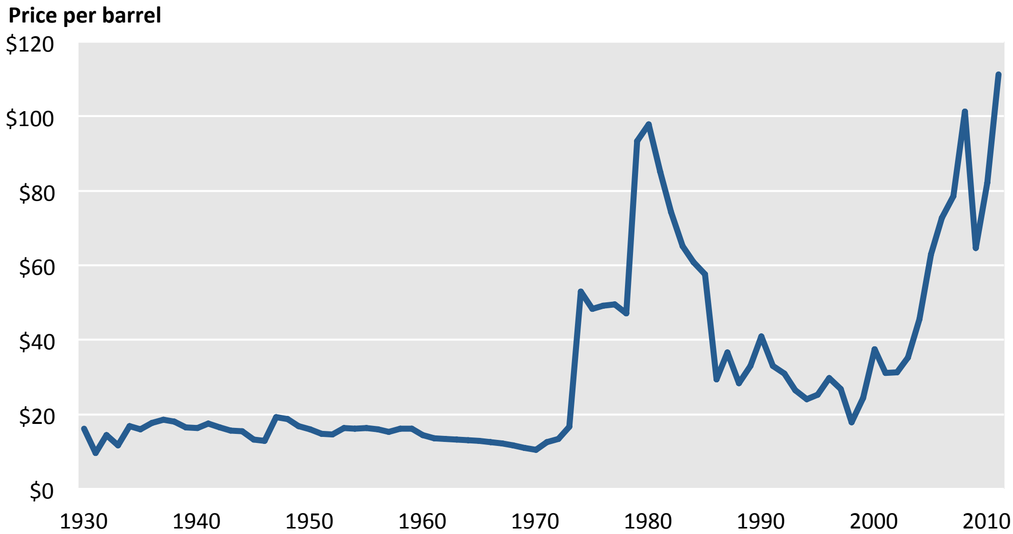

Figure 12. Oil prices per barrel 1930 -- 2011 in real 2011 prices. Discounted with the US CPI.
Source: EIA (2012a), EIA (2012b), BLS (2012)

4.1.3 How much will production cost? (c)

It is clear that the conditions for oil activities in Greenland are more challenging than elsewhere. Climate conditions will incur extra costs, and will require that the oil companies, at least in some areas, use more advanced technology than has been necessary so far, as discussed in chapter 3. It is therefore likely that the recovery cost for the oil will be relatively high.

The International Energy Agency estimates that the average production cost for Arctic oil, including technological progress, will be in the span between $40 and $100 (IEA, 2010). Today, the most expensive oil production sites have a production cost of $50 to $60 (IEA, 2011; Bret-Rouzaut & Favennec, 2011). In the model, we therefore estimate the cost per barrel, c, to be $50. This is a relatively optimistic assumption, which is in accordance with our methodology. However, as the interesting component in our model is the difference between the oil price and production cost, the spectrum of oil prices used could also be interpreted as different costs.

4.1.4 What is the exchange rate? (x)

Since oil is traded in USD, the real exchange rate DKK/USD has an impact on the model. We assume this to be constant at the March 2012 level of about 5,60 DKK/USD.

4.1.5 How high is the government take? (t)

The resource rents from oil findings are usually split between the government and the external investors. The government is considered the owner of the resource, and can therefore expect to be compensated when the resources leave the country. Similarly, the investor wants a return on the exploration and production investment. The income is therefore split into two parts, usually labelled government take and investor take. The government take can include income from a number of different instruments, e.g. royalties, fees and special taxes in addition to ordinary corporation taxes. In most cases, the government also finances part of, or the full, investment through state-owned companies, as e.g. Statoil in Norway, and therefore receives a larger share of the resource rent through ownership.

In addition to the financial investment, an oil exploration also carries very high risk related to if oil is found, reservoir size, oil price and production costs. This risk also has to be split between the government and the external investors. Depending on how the instruments that make up the government share are constructed, the risk is split differently. In principle, the instruments used can be any mix of the following:

1. Fixed fee per licence
2. Royalty on production volume
3. Royalty on revenue
4. Royalty/tax on profit or return on investment
5. Surplus royalty, i.e. royalty on profit or return above a threshold
6. Direct investment

A fixed fee per licence hedges the state against all factors. A royalty on production volume hedges against oil prices and costs. A royalty on revenue hedges against cost. A royalty or tax on profit does not hedge against any of those factors. A surplus royalty is a more complicated variant of a profit royalty, where the royalty is only paid after a certain profitability is achieved. Multiple surplus royalties can be combined to form a progressive government take.

Since a royalty or tax can never be negative, it can be looked upon as a call option on the investment, meaning that it can never be a net loss for the state. Profit and surplus royalties are therefore less risky for the government than the overall project. A direct state investment, on the other hand, lets the state carry a risk proportional to the overall project, where it is possible to even make a deficit.

Figure 13 shows examples of the different types of instruments, and how they relate to the underlying investment.

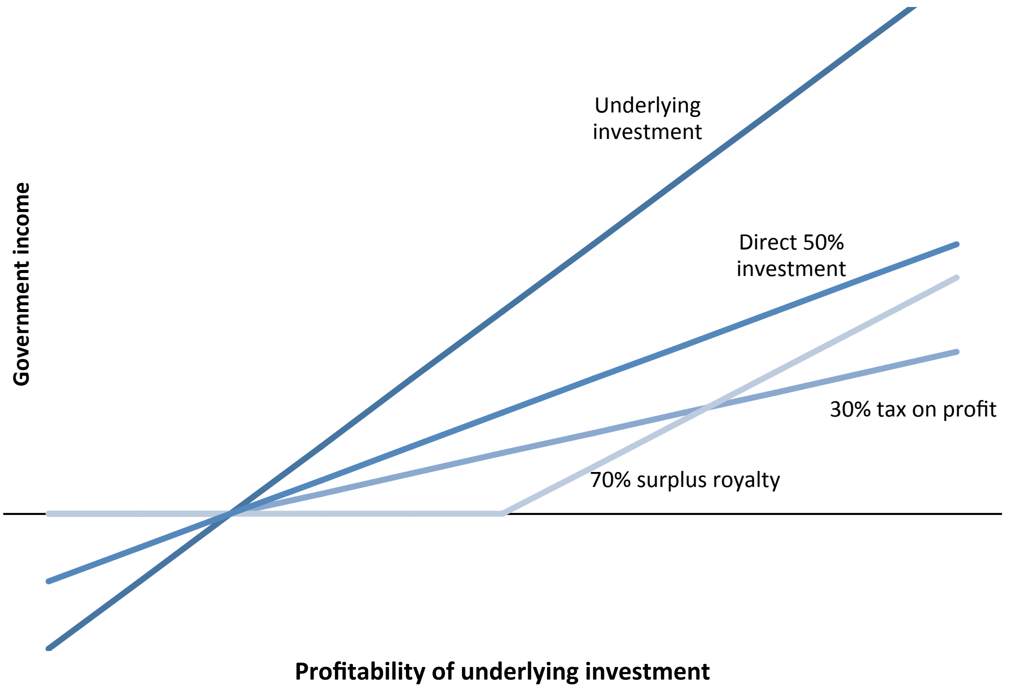

Figure 13. Comparison of direct government oil income using different government take instruments. The surplus royalty applies above a certain threshold.
Source: Own calculations

As risk is costly to bear, a government that wants to avoid risk will have a lower share of the potential income in case the profitability of the oil production becomes high, and vice versa. A surplus royalty decreases the government take when profitability is low. This increases the chance that the oil company will receive a profit large enough to motivate the risk of the investment. Using a surplus royalty could therefore help to attract investors to projects where there is a high probability that the profitability will end up in the lower end of the spectrum. The result is that the state receives a larger share if profitability is high.

Since some of the risk, e.g. the geological risk of reserve size, is possible to hedge, e.g. through investing in exploration in multiple locations, it does not carry the same cost for everyone. In the case of a large country with multiple oil exploration locations, the state might have a lower risk cost than a private exploration company with few active exploration projects. In the case of a small state, with few exploration locations, the state might have a higher risk cost than large multi-national exploration companies. If the instruments of the government take are not carefully constructed to incorporate this, the situation can become non-pareto-optimal, i.e. that both parties would benefit from one party transferring risk to the other party in exchange for a lower return.

In Greenland, the current and upcoming licences all include a government take constituted by a corporation tax, a surplus royalty and a direct investment through the state-owned oil company Nunaoil. (BMP, 2004b, 2006b, 2007b, 2009b, 2009c)

The Greenlandic surplus royalty system consists of three different tiers, which add up to an effective surplus royalty rate of maximum 30% of profits. In appendix 2, we discuss how the effective surplus royalty rates are estimated in our model. Table 3 shows how this effective surplus royalty rate increases when the oil price, and thus profits, increases.

Greenland has a corporation tax of 31,6% and a deductible withholding tax on dividends of 37%. Since tax on dividends is deductible from the corporation tax, PwC (2008) estimates that the effective tax rate for a large-scale project is 35%. We use this estimation in the model. The surplus royalties are deductible in the calculation of these taxes.

In addition to this, the Greenlandic licences include the state-owned oil company Nunaoil as a carried, i.e. non-paying, partner with a 12,5% share in every licence. Nunaoil also has an option to become a paying partner at the same share in a potential production phase. This however, would require the Greenlandic state to also cover 12,5% of the production investment costs. (BMP, 2004b, 2006b, 2007b, 2009b, 2009c) In case Nunaoil becomes a partner in the production phase, this is a direct state investment. Since the decision to invest only needs to be taken if oil is found, the geological risk is already minimised in this situation. Nunaoil is, however, still subject to risks in the form of oil prices and production costs.

Hans Hinrichsen (2012, interview) and the Tax and Welfare Commission (2011) both conclude that the size of a Nunaoil investment would be way too large for the Greenlandic government for the time being, and the Tax and Welfare Commission (2011) recommends not letting Nunaoil participate as a partner in the initial production phase. Nunaoil states itself that it is a long-term goal to take part in production, but that it will not be realistic in the initial stages. (Runge, 2012, interview; Christiansen, 2012, interview) Because of this, we choose not to include Nunaoil participation in our model.

The effective government take therefore includes only the surplus royalty and tax. As Table 3 shows, while the effective surplus royalty rate varies between 15 and 27%, as calculated in appendix 2, this effect is somewhat subdued when including the tax since the surplus royalty is tax deductible. In the table, the effective tax rate, assuming an after-royalty tax rate of 35%, is also calculated. The resulting government take, t, is 45%, 49% or 53% depending on scenario.

Table 3. Effective government take at different price levels.
Source: Own calculations in appendix 2

Price per barrel	$75	$100	$150/200
Effective surplus royalty rate	15%	22%	27%
35% after royalty tax	30%	27%	26%
Total government take (t)	**45%**	**49%**	**53%**

The government take system in Greenland exposes the government to a high risk. If an oil production company exploits large amounts of the resources but only makes a small profit, it would only generate a very small income to the Greenlandic government. Meanwhile, if an oil production company makes a large profit, it would generate a large income to the government. The importance of the legal arrangements to the direct government oil income is shown clearly in the case of Norway, presented in case 2 below.

Case 2. Government Take in Norway

When Norway initiated their first licensing rounds, exploration was taking place in Great Britain simultaneously. Thus, there was a sense that the state had to make an effort to convince the oil companies to explore in Norway. This would increase the probability of findings. As such, in the first licensing rounds the terms were rather favourable for the oil companies. The government take was 10%, while the current government take in Norway is over 80%. Additionally, the Norwegian partly state owned oil company Norsk Hydro was only partner in some of the licensing blocks. As it happened, the first major oil finding, Ekofisk, was made in one of the blocks where Norsk Hydro was partner. Additionally, the largest oil and gas finds have been made in blocks that were not part of the first licensing rounds. In these blocks, the terms were more favourable for Norway. Ryggvik (2010) argues that the Norwegian oil experience could have been very different without these lucky coincidences. (Ryggvik, 2010)

4.1.6 When can production start and stop? ($n_{first\text{-}year}$, $n_{last\text{-}year}$)

No oil has yet been found in Greenland and it is therefore very difficult to estimate when production will start, which in turn of course still is hypothetical. Since no exploration drillings will take place in 2012, Minik Rosing, geologist at GEUS, estimates that potential production will probably not begin until at the earliest 2025 (Sermitsiaq.AG, 2012). Following our assumption methodology and considering that this parameter is uncertain but has a relatively small impact on the result, we use this optimistic starting year for production in West Greenland.

The licences currently active in West Greenland are all from the years 2004-2010. The licences for East Greenland will be awarded in 2012 and 2013. The difference in time between licences in West and East Greenland is therefore between 2 and 9 years. Since the licensing rounds are held later in East Greenland and production there will require more advanced technology than in West Greenland, we assume that production in East Greenland will start 10 years after West Greenland, i.e. in 2035.

We assume production in both West and East Greenland to last 30 years. This estimation is based on the Bureau of Minerals and Petroleum (BMP), which uses a 30-year length on its production licences (BMP, 2004b, 2006b, 2007b, 2009b, 2009c). It is also supported by a comparison between the implied production per day in Greenland and other oil producing countries.

Production from individual oil fields usually follows a standard production profile where production peaks after a short period, stays there for a certain time and then declines. When several oil fields are aggregated, it is much harder to predict the aggregated production profile. There are a few attempts, e.g. Hubbard's curve, but there is no scientific basis for these. (Bret-Rouzaut & Favennec, 2011) We therefore model oil production to be constant over time with payments at year-end. This gives a reasonable approximation of discovery, peak and decline of several oil fields in the areas.

4.1.7 What is the discount rate? (i)

To convert the state income to a net present value, we discount the values at a discount rate. Greenland has decided to invest the oil income in a fund, inspired by the Norwegian Government Pension Fund. The concept and cause for the creation of the fund is discussed in more detail in chapter 5. In the model, we determine the discount rate on the government income by the real return on the fund.

The expected real return rate of the fund depends on its composition, and thus its risk exposure. The Act on the Greenlandic Mineral Resource Fund (2008) states that the fund should invest 75-85% of its capital in interest-related instruments and 15-25% in equity-related instruments. As a comparison, the Norwegian Government Pension Fund has had a 40-60% share of equities since 1998 (NBIM, 2012). Since it is generally assumed that interest-related instruments have a lower yield than equity-related instruments, the return of the Greenlandic Mineral Resource Fund will therefore probably be somewhat lower than that of the Norwegian Government Pension Fund.

We assume that the fund uses the following investments: 40% high grade long-term government bonds, 40% medium grade long term-government and corporate bonds and 20% equities.

A good proxy for a high-grade long-term government bond is the 30-year US Treasury Inflation-Protected Securities, which in March 2012 have a yield of 0,9% in real terms. (Bloomberg, 2012) Medium grade bonds are estimated to have a real return of 2% and equities are estimated to have a real return of 4%.

The discount rate, i, is therefore estimated to be the weighted sum of these, which is about 2%. This is somewhat lower than the historical real return of the oil fund of Norway, 2,42% (NBIM, 2012), which is reasonable as the Norwegian oil fund has a higher share of equities. A return of 2% is also consistent with the assumptions used in the Tax and Welfare Commission (2011).

4.1.8 Model results

Now that the parameters in the model are presented, we show the results. Figure 14 shows the net present value of the government income from the oil resources. The four lines represent four different oil prices. On the y-axis is the income for the government in billion DKK, and on the x-axis the probability of getting a certain amount or more.

The figure shows, e.g., that with an oil price of $100 per barrel, there is a 52% chance that the value of the oil to the government is at least 250 billion DKK. The oil price needs to be at least $150 per barrel for the value to have any real chance of being more than 1.5 trillion DKK.

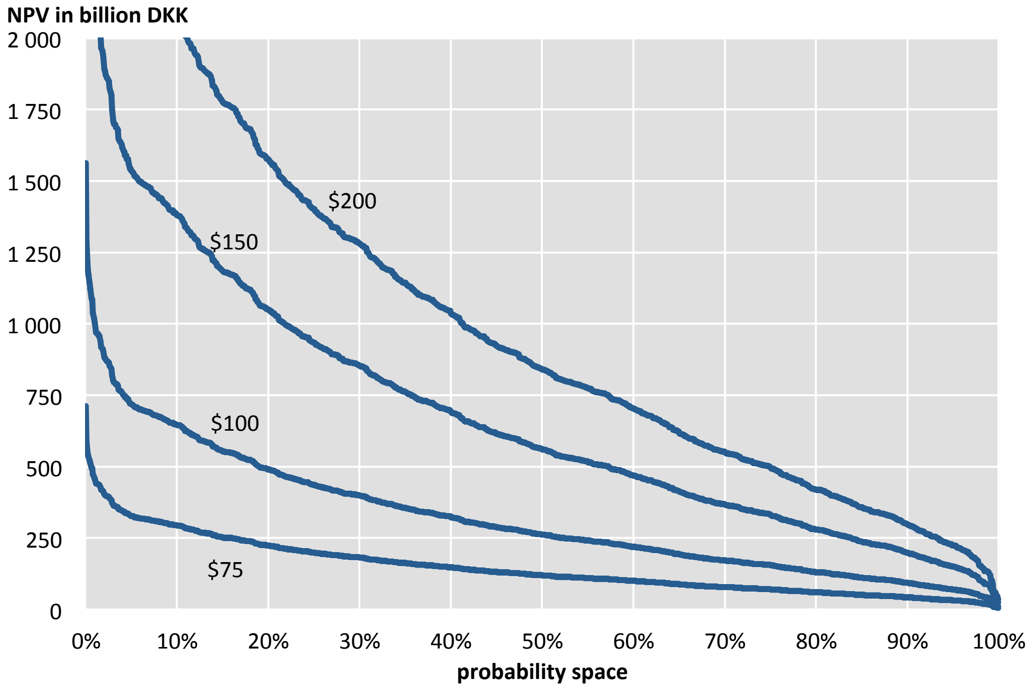

Figure 14. The net present value of the direct government oil income in billion DKK at four different oil prices in dollars per barrel.
Source: Own calculations

To assess whether the assumptions about economic recoverability and the time span are realistic, we calculate the implied daily production and compare this to other oil producing countries. The 5th, 50th and 95th percentile of the production per day implied by a recoverability modifier of 29% and a production time span of 30 years are presented in Table 4. We compare them to the production of 53 oil producing countries (BP, 2011).

Table 4. Implied production in Greenland
Source: Own calculations based on BP (2011)

	5th percentile	**50th percentile**	**95th percentile**
Greenlandic daily production	935,000 barrels	359,000 barrels	97,000 barrels
World production ranking	23 of 53	35 of 53	50 of 53
Comparable to	Indonesia	Thailand	Italy

The results seem reasonable. Greenland has no chance of becoming one of the top oil producing countries, but has a reasonable chance of establishing itself in the middle of the chart.

4.2 Four Scenarios for a Self-Sustaining Greenland

The previous section estimates the direct government oil income. In order to understand if this is sufficient to build a self-sustaining economy in Greenland we need to put this into perspective. Here we construct four scenarios for a self-sustaining Greenlandic economy. In the next section, we compare these to the results from 4.1. The scenarios are:

1. Replacing the Block Grant. In this scenario, the fund reaches such a value that the withdrawal from the fund replaces the current block grant. Replacing the block grant allows economic independence from Denmark, and allows a self-sustaining Greenland. Because of the future demographic challenges, this scenario is not enough to balance the government budget in the long term with current policies.

2. Overcoming the Demographic Challenges. In this scenario, except for replacing the block grant, the fund also finances the government budget deficit caused by the demographic challenges discussed in section 2.4. In other words, this allows a self-sustaining economy including covering the increased welfare expenditure caused by an ageing population until 2035.

One problem with the block grant today is that it is frozen in real terms. As the economy grows, government expenditure grows accordingly. In this case, however, a large part of the government income will not. This creates an extra deficit. A solution can be to replace the block grant with an income that grows with the economy. Such an income is called a permanent income, and is discussed further in section 4.6.1.

3. A Permanent Income. This scenario includes constructing a permanent income from scenario 2. This allows the withdrawal from the fund to follow the estimated GDP-growth. As the income is permanent and grows with the economy, it will constantly top up the Greenlandic consumption from a source that is independent from Denmark.

4. The Oil Bonanza. In this scenario, the fund is so large that it can finance a permanent income starting at the size of two block grants on top of the budget deficit. Since the consumption today is financed to about one third by the block grant, this scenario does, roughly speaking, increase living standards with about one third. This puts Greenland in the top 10 of countries in purchasing power-adjusted GDP per capita along with Norway and Luxembourg.

The scenarios all imply a self-sustaining Greenland. Scenario 1 and 2 do, however, not balance the government budget in the long term with current policies and growth. Scenario 3 takes future growth into account and therefore balances the budget long term with current policies and growth. Only scenario 4, however, means a drastic improvement in the government finances.

Table 5 presents the net present value, i.e. the cost, for each of these scenarios. The calculations are provided in appendix 3.

Table 5. Net present values of the scenarios
Source: Own calculations, see appendix 3

Scenario	Total
1. Replacing the Block Grant	216 billion DKK
2. Overcoming the Demographic Challenges	438 billion DKK
3. A Permanent Income	654 billion DKK
4. The Oil Bonanza	1086 billion DKK

In the next section, we compare the cost of these scenarios with the potential direct government oil income that we calculated in 4.1.

4.3 How Likely Are the Scenarios?

Here we compare the net present values of the potential direct government oil income with the different scenarios. Through this, we can establish how likely the scenarios are at the chosen oil prices. Table 6 presents the result of this analysis.

Table 6. Probabilities for the scenarios
Source: Own calculations

	<$50	$75	$100	$150	$200
1. Replacing the Block Grant	-	21%	61%	88%	96%
2. Overcoming the Demographic Challenges	-	1%	25%	63%	79%
3. A Permanent Income	-	-	9%	42%	63%
4. The Oil Bonanza	-	-	1%	19%	38%

As Table 6 shows, at current oil prices of about $100 per barrel only the first target seems reasonably achievable. At $100 per barrel, there is a 61% probability of achieving a self-sustaining Greenland. However, the other scenarios seem unlikely. The possibility for Greenland to become significantly richer, the oil bonanza scenario, is negligible at current oil prices. The oil price needs to reach a level of $150 or $200 for scenarios 2-4 to be plausible.

The results are uncertain on two levels. The results both *are* uncertain and *show* uncertainty. Firstly, the results in Table 6 are based on a number of assumptions and incorporate uncertainty from the geological data. Our model manages this through including a sensitivity analysis of the geological data and the oil price. Additionally, we document our calculations to allow others to update them as new information becomes available. Secondly, the results show that it is uncertain if Greenland can become self-sustaining.

The conclusion that can be drawn is that the current optimism surrounding the oil sector is exaggerated. It is unlikely that Greenland will become significantly richer. If Greenland *should* receive an income that makes a self-sustaining economy possible this would be a great step towards increased independence. Such a large government income is, however, not unproblematic. This is explained in the next section.

4.4 The Dutch Disease

Direct government income from natural resources can have negative effects. These effects are usually collectively referred to as the *resource curse*. The most prominent component of this is the Dutch disease, which is presented in the following. The Dutch disease is then used to analyse how the block grant affects Greenland today. We continue the discussion about the resource curse in the section concerning income volatility in 4.5 and in chapter 5.

4.4.1 The Dutch Disease Theory

Most, if not all, of us would be delighted to have a higher wage than we do. The problem for us is that our wages are set on a market that restricts them to what our labour is worth, at least in theory. If the wages increase in one country, this has to be compensated through higher prices. This, in turn, makes everything that is produced in that country more expensive to foreigners. If the quality of the produce does not motivate the higher price, exports become uncompetitive and the exporting industry suffers. If money flows into a society from a natural resource rent, there is a possibility that this money is used to increase wage levels above what is motivated by the productivity of the workforce. As higher wages are something that people desire, it is even likely that it happens. The effect from this will be a less competitive economy.

This discussion can help to understand the phenomenon of the Dutch disease. The idea of the Dutch disease was developed in the 1970s to explain why the Netherlands experienced a decline in its manufacturing industry after discovering natural gas in the North Sea in 1959 (Economist, 1977). As in the discussion above, the Dutch exporting industry suffered when resource rents started to flow into the economy. The Dutch disease includes two effects: the resource movement effect and the spending effect.

To explain these effects, it is assumed that a country has two traded sectors, the natural resource sector and e.g. manufacturing, as well as one non-traded sector, e.g. services. The effects occur when the resource sector experiences a boom.

The Resource Movement Effect. The boom in the resource sector will lead to higher demand for labour in that sector, thereby shifting labour from the manufacturing and non-traded sector. This is called the *direct de-industrialisation*. The equilibrium wages will also increase. (Corden & Neary, 1982)

The Spending Effect. The second effect starts as the consumption in the country increases, because of the higher wages. The increased consumption leads to higher prices in the non-traded sector, but not in the traded sectors as those prices are set on the world market. This leads to a higher demand for labour in the non-traded sector, and further wage increases. (Corden & Neary, 1982)

Both these effects lead to higher wages, which lowers demand for labour in the manufacturing sector. This is called the *indirect de-industrialisation*. The direct and indirect de-industrialisation both impact the manufacturing sector negatively. The services sector, on the other hand, sees a negative impact of the resource movement effect, but a positive impact of the spending effect. Depending on which of these effects is the strongest, the services sector can either gain or lose from the Dutch disease. (Corden & Neary, 1982)

A de-industrialisation is in itself not a problem. However, if the reduced traded sector has higher Learning By Doing-effects than the growing sector, i.e. natural resources or services, this will have negative effects on economic growth. Gylfason (2000) states that primary production of natural resources tends to involve less high-skilled labour than other industries and uses this to explain why growth is generally lower in natural resource abundant countries.

One result of the Dutch disease is that price levels increase in the non-traded sector, causing a real appreciation. The Dutch disease can therefore be measured by measuring the real exchange rate or by observing price increases in the non-traded sector in relation to the traded sector.

4.4.2 Does Greenland Already Suffer from the Dutch Disease?

Potential oil findings in Greenland could cause a Dutch disease to emerge. However, Paldam (1994, 1997), OECD (1999) and Lund (2011) all suggest that Greenland already suffers from the Dutch disease. This hypothesis has, however, not been tested in recent years. Therefore, we will here try to determine if and to what extent, this hypothesis holds.

To start with, it is important to notice that Greenland lacks the prerequisite for the Dutch disease outlined above. Greenland does not have a booming natural resources sector. What it does have, however, is a block grant from Denmark that increases consumption. A transfer of this type would cause the same spending effect as discussed above.

As noted earlier, the Dutch disease can be measured through the real exchange rate. Since the Greenlandic economy is so small relative to the Danish, the only way to test this is through estimating the price difference between Greenland and Denmark. Denmark is Greenland's largest trading partner by far and contributes about 70-80% of the Greenlandic import and export.

Such a price comparison is a complicated task and was last made in 1994. We therefore construct an estimation of the price differences using the consumer price index (CPI) for Greenland and Denmark and prior price comparisons as reference points. The methodology is outlined more in detail in appendix 4.

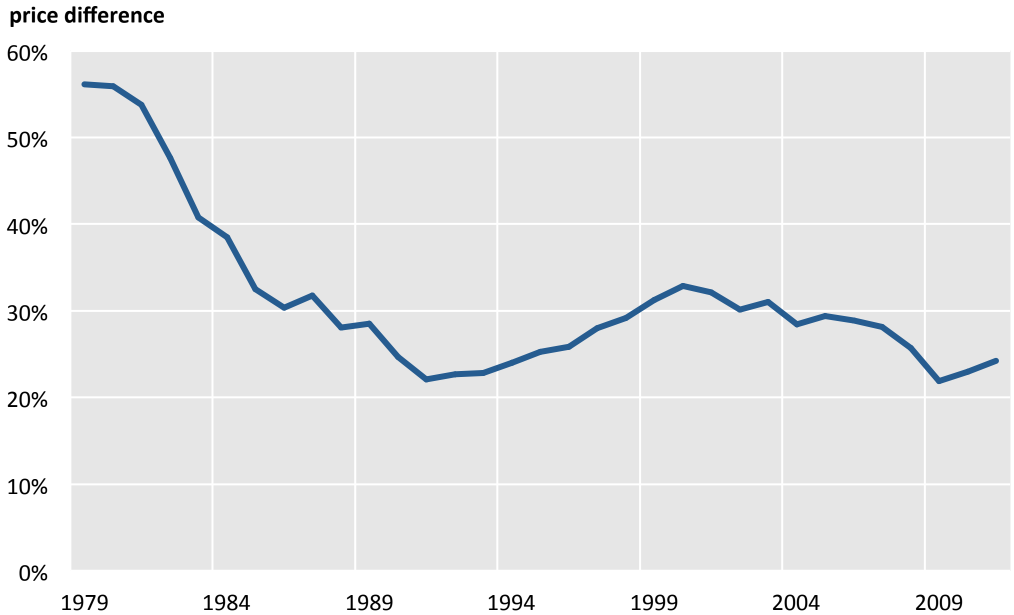

Figure 15. Approximation of the price level difference between Greenland and Denmark.
Source: Own calculations (outlined in appendix 2) based on Statistics Greenland (1994), Paldam (1994), Statistics Greenland (2012) and (2012)

Figure 15 shows that the real exchange rate has fluctuated modestly between 1994 and 2011 with the 2011 Greenlandic price level being 24% higher than the Danish. If a spending effect caused by the block grant causes the price level difference, there should be a correlation between the size of the block grant per capita, i.e. how much consumption can be raised per capita, and the price level difference. We test this hypothesis and present the results in Figure 16. There seems to be a strong correlation (R^2 = 0,83) between the size of the grant per capita and the price level in Greenland. The block grant per capita is used instead of the block grant as a share of GDP since the GDP-data for Greenland fluctuates, introducing noise into the plot.

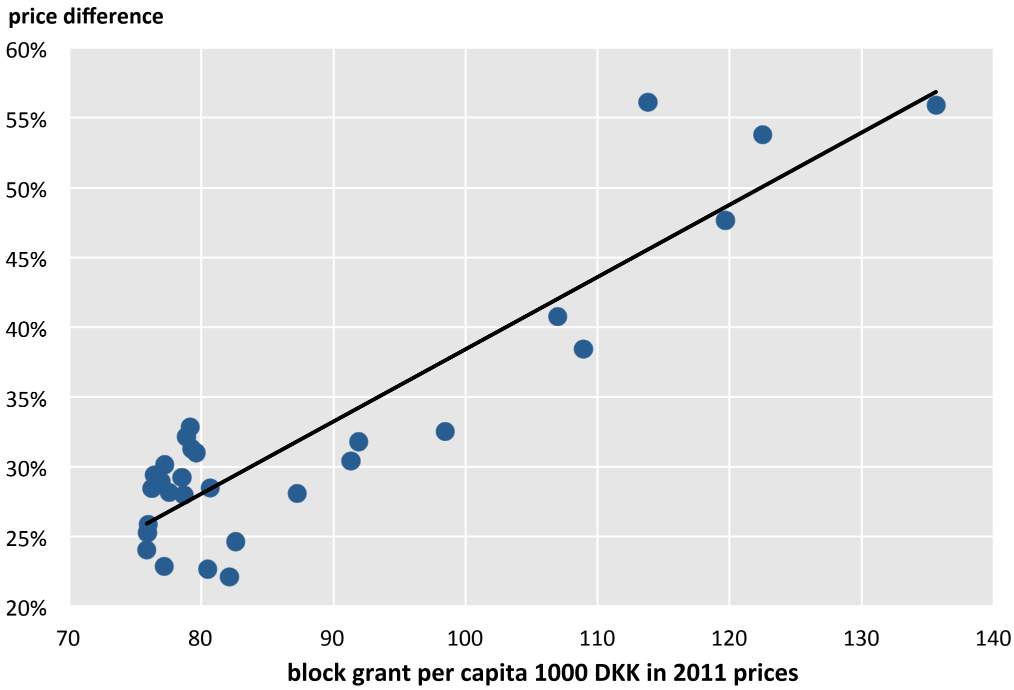

Figure 16. Correlation between the size of the block grant per capita and the price difference between Greenland and Denmark.
Source: Own calculations based on Statistics Greenland (1994), Paldam (1994), Statistics Greenland (2012) and Denmark Statistics (2012)

Another way of testing the hypothesis of a spending effect in Greenland is to look at the size of the non-traded sector in comparison to the traded sector. This is estimated by looking at the export share of GDP. Gylfason (1998) notes that the export share of GDP tends to be higher for small countries because of limited possibilities for internal trade. The average export share for countries with a population of less than 2 million was 52% (Gylfason, 1998). In Greenland, this share was significantly smaller: 21% for 2007 (Statistics Greenland, 2012).

We thus show that there is significant evidence of a spending effect in Greenland. This manifests itself in a high real exchange rate, which seems to be correlated to the block grant size, and a low export.

4.5 Income Volatility

World market prices on natural resources are volatile, particularly for oil as seen in 4.1.2. This leads to another component of the resource curse: income volatility. Natural resource income is often more volatile than price levels on manufactured and processed goods. If a government is very dependent on natural resource exports, it has very volatile income streams. This can cause problems for long term planning. Bad management of the varying incomes can lead to large expansions in good years followed by deep cuts in worse years. In this way, booms and busts are exaggerated. (Collier & Dehn, 2001)

As noted in 2.2, the block grant that Greenland receives from Denmark is more or less constant from year to year. This means that the block grant has a stabilising effect on the economy. If the block grant is replaced by income from oil, this changes. In order to avoid the income volatility, an arrangement is necessary to regulate it. This is discussed in the next section.

4.6 Managing the Spending Effect and Income Volatility

Both the spending effect and income volatility stem from an income. These can be managed through a fund that creates a buffer between the income and the government budget. This makes it possible to control how much of the income that is introduced into the economy and thereby the extent of the spending effect. Additionally, the fund absorbs the income volatility. Theory on how such a fund can be constituted is presented in 4.6.1 followed by a description of the proposed Greenlandic Mineral Resource Fund.

4.6.1 Sovereign Wealth Funds and the Permanent Income Model

A *sovereign wealth fund* is, in principle, a fund that is owned and managed by the government of a country. In oil producing countries, sovereign wealth funds are used to stabilise an income and sometimes also to save wealth for future generations. (IMF, 2007) Based on which of these objectives is regarded as most important, sovereign wealth funds can be divided into two categories.

The first category includes stabilisation funds, which are used to avoid price volatility on primarily natural resources or commodities. The second type is long-term saving funds. These convert a temporary income from natural resources to financial assets, with the purpose to share the wealth with future generations (IMF, 2007).

A well managed sovereign wealth fund accumulates surpluses and incurs deficits when the price of oil is above or below the average. Surpluses are then used to pay the debts, and the debt-to-GDP ratio is kept constant over a cycle. This sends a strong signal that the government is committed to long-term financial stability. (Skidelsky, 2003) If the sovereign wealth fund is a long-term saving fund, the permanent income model can be used to calculate the sustainable yearly spending from the fund.

The *permanent income model* is a way to convert a temporary income to a permanent income: a perpetual income that grows with the economy. The main benefit of a permanent income is that it balances the trade-off between current and future generations by constructing an endless and constantly growing income stream from a temporary income, e.g. natural resources. This is therefore a good model to control the outflow from a sovereign wealth fund to the government budget.

The permanent income is expressed as a percentage of GDP, meaning that it will grow with the same pace as GDP and as such constitute a permanent addition to the consumption. The model relies on Milton Friedman's assumption that a permanent income generates higher wealth than a temporary income even if the temporary income is higher. (Basdevant, 2008)

The permanent income is calculated by first estimating the net present value of the future incomes and calculating an annuity (A_t) from that. Then, the government spending level at year t (G_t) that allows the fund to grow at such a pace that the government spending can grow with the GDP growth (g) is estimated using a predicted fund interest (i). (Basdevant, 2008) The permanent income can thus be expressed:

$$G_t = \frac{i-g}{1+i}$$

A strict implementation of the permanent income model leads to very low government spending relative to savings when the income from the resources is high. If applied when resource income is already used in the government budget, it might lead to drastic government spending cuts. (Basdevant, 2008)

4.6.2 The Greenlandic Mineral Resource Fund

In late 2008, the Greenlandic Parliament passed the Act on the Greenlandic Mineral Resource Fund, i.e. a sovereign wealth fund. The act states that the fund will be set up when income from natural resources exceed 5 million DKK. (Act on the Greenlandic Mineral Resource Fund, 2008) The current administration has proposed to increase this breaking point to 75 million DKK (Government of Greenland, 2012).

The act states that only the dividends from the fund should be used for financing the welfare in the future, not the oil income directly. The fund is thus a long-term saving fund. However, it is deemed acceptable to use the oil income directly if it is used for financing the takeover of new areas of responsibility from the Danish state, or to replace the block grant. The act also allows the self-rule government to finance costs related to mineral resource activities with money from the fund. (Act on the Greenlandic Mineral Resource Fund, 2008)

The Tax and Welfare Commission (2011) discusses the fund and concludes that it might be acceptable to use it for gaining more independence. However, the possibilities for using the fund to invest in mineral resource activities are too wide. This makes it possible to invest in risky mineral resource projects. (Tax and Welfare Commission, 2011)

4.7 Potential Dutch Disease Effects on the Scenarios

We now return to the four scenarios for a self-sustaining Greenlandic economy. Direct government oil income has, as discussed above, negative effects in the form of income volatility and the Dutch disease. How do they impact the scenarios?

By using the Greenlandic Mineral Resource Fund as a buffer, the income volatility can be completely avoided in Greenland. The spending effect can never be avoided, as long as oil income is introduced into the economy. It can be controlled, however, since there is a relationship between the size of the effect and how large the spending of the income is. The resource movement effect, on the other hand, cannot be avoided at all.

In this section, we therefore estimate the effects of the spending and resource movement effect on the scenarios.

We show in section 4.4.2 that the *spending effect* already is present in Greenland and that the size of the effect is directly related to the amount of money brought into the economy. Figure 16, presented earlier, shows the plot of the price level difference between Greenland and Denmark over the historical values of the block grant.

The figure shows that the price level in Greenland relative to Denmark correlates with the size of the block grant. If this holds for direct government oil income, it is possible to use this figure to estimate the order of magnitude of the spending effect.

We estimate the spending effect of the four scenarios using the trend line in Figure 16. Table 7 presents the results. The calculations are extremely rough estimations but they give an indication of how increasing government income could affect the price level in Greenland. As Table 7 shows, the spending effect can become very much larger than today. In the scenarios 2, 3 and 4 the spending effect grows two to three times compared with today. This would have drastic implications for the Greenlandic economy.

Table 7. Implied spending effects in the scenarios.
Source: Own calculations. The Price difference is the implied price difference between Greenland and Denmark.

Scenario	Yearly income (million DKK)	Income/capita (DKK)	Price difference
1 Replacing the Block Grant	4,300	76,000	26%
2 Overcoming the Demographic Challenges	4,300-7,600	76,000 - 134,000	26% - 56%
3 A Permanent Income	4,300-7,600	76,000 - 134,000	26% - 56%
4 The Oil Bonanza	8700-10,700	152,000-187,000	66% - 84%

The size of the *resource movement effect* is dependent on how high the demand is for Greenlandic labour in the oil industry. If demand for labour is low, or if it is imported from abroad, the resource movement effect is negligible. If it is high, however, it leads both to a direct de-industrialisation and an even more pronounced in-direct industrialisation as wage levels are higher in the oil sector.

The arguments for that this would happen is that the number of trained people in Greenland, e.g. craftsmen, academics etc., is very small, and that the competition for them would be fierce. Both Naaja Nathanielsen (2012, e-mail correspondence), member of the Greenlandic Parliament and Mikael Thinghuus (2012, interview), CEO of Royal Greenland, express concern that skilled labour might move from the traditional fishing sector to the oil industry. Against this could be put the argument that the oil industry in general employs few people, and that the employees are generally international and highly specialised. The Greenlandic labour force might be unsuitable because it lacks the necessary expertise. We can therefore not determine the size of this effect.

We conclude by remembering that the effect of a price level increase is that the exporting industry becomes less competitive on the world market. Greenland already has a small exporting sector. However, a further increase in the price level would probably make it difficult also for the remaining exporting companies. There is a risk that this would affect the fishing cluster which today is both the largest exporter and employs around 25% of the workforce, as mentioned in section 2.3. Development of other industries, such as tourism and mining, could also be obstructed. As all scenarios imply that a self-sustaining Greenlandic economy requires an income level at least at the block grant level, there is no scenario when the spending effect is smaller than today.

4.8 Economic Conclusions

We estimate the direct government oil income in Greenland in this chapter and show that there is a 61% probability of replacing the block grant with current oil prices. This indicates that it is possible that Greenland can become self-sustaining. However, replacing the block grant is not enough to keep the government budget balanced assuming current policies. Additionally, the possibility for Greenland to become significantly richer, the oil bonanza scenario, is negligible at current oil prices. We therefore conclude that the current optimism surrounding the oil industry is exaggerated.

Should the direct government oil income nevertheless be considerable, the management of this will be central. It is important to note that all the scenarios imply a spending level at least comparable to today. This means that the Dutch disease effects will not be reduced in any of the scenarios. If spending is increased, the Dutch disease increases correspondingly. This would have negative effects for the exporting fishing industry and other potential industries. However, it is here interesting to note the difference between the resource movement and the spending effect and how this relates to Greenland.

The Dutch disease theory supposes that there is a booming natural resource sector and an exporting manufacturing sector that can decline. In Greenland, there is neither so far. Therefore, Greenland only suffers from one of the Dutch disease effects: the spending effect. The indirect de-industrialisation caused by the spending effect is a problem in Greenland as it hinders the development of new industry. The resource movement effect, on the other hand, does not occur as there is no booming sector. In this rather special society, what would be the effect if an oil sector is introduced?

The direct de-industrialisation caused by the resource movement effect is a problem particularly if the industrial sector that declines has lower learning by doing-effects than the booming natural resource sector. In Greenland, the only major sector that can decline is the fishing industry. As the fishing industry today has a substantial hidden unemployment, it is possible that the oil sector would be more productive and have higher learning by doing-effects. In that case, the resource movement effect would lead to a productivity increase.

If the resource movement effect is positive in the case of Greenland, it would be advisable to try to enhance this by encouraging people to find work in the oil sector. It is likely that this would lead to higher wage levels and therefore to an increasing Dutch disease. This could, however, be managed by controlling the spending effect through lower outtake from the Greenlandic Mineral Resource Fund. If this is done, it is possible that productivity would be increased without an increased Dutch disease. This reasoning suggests that the spending effect is the primary cause of concern for Greenland, but also that there might be a way out of the Dutch disease caused by the block grant if the oil sector develops in a favourable way.

The government take system that Greenland has chosen, with surplus royalties and corporation taxes, is a system that leverages the geological risk and exposes the direct government oil income to market factors such as the oil price. This higher risk-taking might be non-pareto-optimal, since Greenland can not hedge itself against the geological, technical or market risks. This poses the question why a small country decides to expose itself so heavily to such a risky project. On the face of it, this seems irrational, since the risks are non-diversifiable for Greenland, but could be diversifiable for international oil companies.

It is possible that there is a political explanation. We explain this through a thought experiment. A high-risk strategy brings the possibility to achieve a huge profit while a low-risk strategy guarantees a low profit. If a huge profit is required for the desired outcome, it is rational to aim for the risky strategy.

The superior aim of Greenlandic politics is to achieve independence from Denmark at some point in the future. This is only possible if the economy is self-sustaining. If we assume that the only possibility of achieving this is through a very favourable outcome in the oil sector, the only scenario that includes this possibility will be risky. Therefore, it might be rational for Greenland to aim for this risky strategy. The result is that there at least is some possibility to achieve independence. Politicians may also count on help from Denmark in case the outcome is very unfavourable, thereby minimising the potential downside.

5 Institutional Conditions

Chapter 4 analyses the possibility for Greenland to become a self-sustaining economy through the direct government oil income. The conclusion is that it is uncertain that this will be enough, and that it is a risky strategy to rely on this alone. Apart from the direct government oil income, however, an oil industry in Greenland could contribute in other ways to economic development. This can e.g. be through job creation, the forming of related industry and services. The case about Norway below explores this.

Paradoxically however, researchers have identified an empiric negative correlation between natural resource abundance and economic growth. This is commonly referred to as the resource curse. Some of the aspects of the resource curse, primarily the Dutch disease, are discussed earlier in 4.4 and 4.5. The concept of the resource curse is expanded in the next section to include more aspects.

In order to avoid the resource curse, economic research points to the importance of institutions. Institutions are a concept in the field of institutional economics. They include the rules and authorities that form behaviour in the economy and can be formal or informal. Formal institutions are institutions that are readily observable through written documents, rules or authority, while informal institutions describe social norms and culture. Institutional quality is thought to explain why some countries are rich and others poor, even if they have similar resources. The institutions affect an economy through providing incentives. Generally speaking, institutions can either provide incentives for citizens to produce or to take. The incentives in a society are central to how productive the economy will be. (Knack, 2003; Olson, 1996)

How institutions can help to avoid the resource curse is discussed in 5.2. Finally, the institutional theory is used to analyse how well the Greenlandic institutions can manage the resource curse.

Case 3. What Really Creates Value

One key feature of the successful oil strategy in Norway has been the creation of a national oil industry to build know-how and expertise within the country. Foreign firms dominated the first waves of exploitation in Norway while Norwegian workers provided simple labour. Soon, however, Norwegian firms became competitive and managed to dominate in later expansions. This was to a degree supported by the Norwegian state, but also a result of that Norway had a strong shipbuilding and seafaring tradition, which could be put to use in the new industry. (Ryggvik, 2010)

The Norwegian government emphasises that the employment and hard work of ordinary Norwegians is the fundament of the successful Norwegian economy. The direct government oil income is only a small part of the future wealth of the country. This is illustrated in the circle diagram below, taken from the Norwegian government homepage. The current and future work performed by the Norwegian people accounts for 85% of the future wealth while the oil wealth only accounts for 4%. (Government of Norway, 2012a)

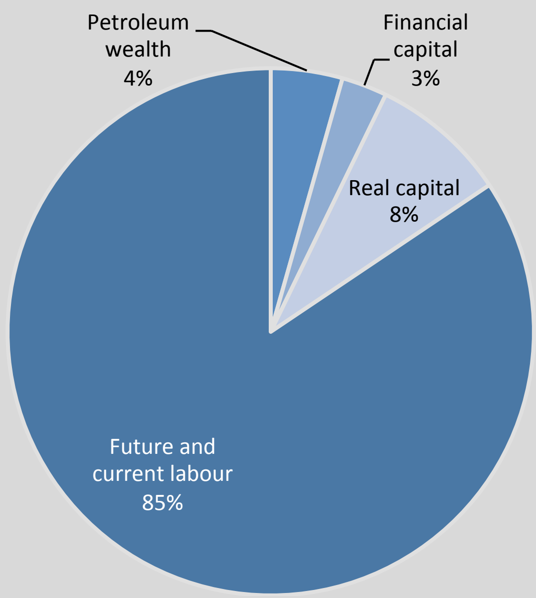

Figure 17. Norway's future wealth by category.
Source: Government of Norway (2012a)

5.1 The Resource Curse

The term resource curse was first used by Auty (1993) and is sometimes also referred to as the paradox of plenty. It has its grounds in economic research that has identified a negative empiric correlation between natural resource abundance and growth. (Sachs & Warner, 2001; Mehlum et al., 2006; Gylfason 2000). A regression analysis showing this is found in Figure 18 below.

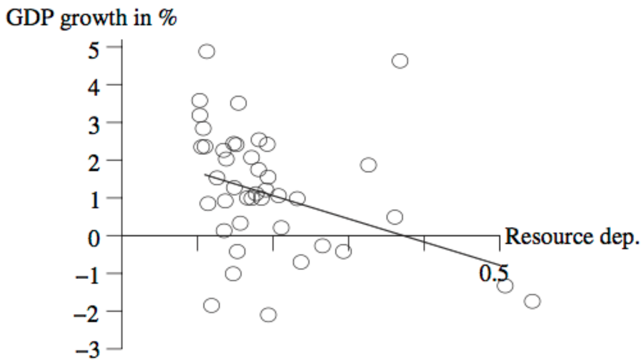

Figure 18. Resource dependence and growth.
Source: Mehlum et al. (2006)

While the empirical correlation between natural resources and growth is well documented, several theories have been proposed to explain it. The Dutch disease and income volatility are already discussed in 4.4 and 4.5. However, plenty of other effects have been suggested. In this thesis, we focus on the concept of rent-seeking which incorporates many of the institutional effects.

The basis for rent-seeking is when governments give incentives for citizens to divert wealth from others, *taking*, instead of producing it, *making*. This can take many forms. Corruption in business and government is an example of this (Gylfason, 2000; Tornell & Lane, 1999). One effect of rent-seeking is that institutions weaken and this, in turn, has a negative effect on growth (Gylfason, 2000).

One effect of rent-seeking is that industry can start putting effort into getting support from the state instead of becoming competitive on the world market. Gylfason (2005) suggests that companies align themselves with the state when the state becomes wealthy from natural resource income. The producers are then rewarded by the state through export subsidies or tariffs that make the national industry more competitive on the domestic market. This, however, has a negative impact on growth. Rent-seeking thus harms growth as focus is put on unproductive activities. (Gylfason, 2005)

Rent-seeking can also impact the politicians' ability to take rational decisions. Instead of being careful, natural resource rich governments might try to spend their way out of economic downturns as they have the resources and as this might be popular with the electorate. This often results in an indebted economy and high inflation. This is one explanation why rent-seeking contributes to failed economic policies. (Gylfason, 2005)

Rent-seeking can impact the ability of the government to handle a sovereign wealth fund, like the Greenlandic Mineral Resource Fund. A risk is that the fund is used as a means to combat the Dutch Disease, even though the hydrocarbon income itself is the cause for it. When the exporting industry becomes less competitive due to currency appreciation, and people start to lose their jobs, it is possible that the fund reserves are used to alleviate this through subsidies. This locks the country into an uncompetitive economy. (Skidelsky, 2003) The mechanism relates to Gylfason (2005) and the observation that natural resource rich countries fail with their economic policies. A small country that has experienced such mismanagement is the Faroe Islands, as discussed below in case 3.

Case 4. A Resource Fund in a Small State

One example of mismanagement of a fund in a small state comes from the Faroe Islands. The Faroe Islands is an island group in the Northern Atlantic. The Faroe Islands is a part of the Danish realm and receives a block grant every year from Denmark, like Greenland does. The population is around 50,000 and the economy is heavily based on fishing. (Paldam, 1994)

The Faroe Islands experienced a fishing boom in the 1980s. A resource fund was started with the intention to even out the income from years with higher fish prices to years with lower. After a while, however, money from the fund was used both for investing in a more efficient fishing fleet and for public spending. In addition to this, the government borrowed around 165% of GDP. The fund was thus used to fuel a gigantic fishing bubble. The inflow of money increased the Dutch disease in the country to a point where the only business that survived was the fishing industry and state owned firms. (Paldam, 1994)

The heavy investment in the fishing industry led to overfishing and the collapse of the fish stocks at the end of the 1980s. As the economy was totally dependent on fish, the result was a total collapse and a reduction in GDP of about one third. Eventually, this debt was taken over by Denmark. (Paldam, 1994)

5.2 How to Manage the Resource Curse

While both the spending effect and income volatility can be managed through a fund, as discussed in section 4.6, the fund is affected by the society that it exists in. There are examples of countries that have created funds but not managed to escape the resource curse, indicating that this is not enough. In the following, we discuss how institutions can help avoiding the resource curse. The suggestion is that institutions can limit rent-seeking and ensure that the fund is used as intended.

Mehlum et al. (2006) put forward the argument that the effect on growth by natural resources is conditional upon having bad institutions in the first place. Using an index of institutional quality, they show that the negative correlation between resource abundance and economic growth does not hold for countries above a certain institutional quality threshold. The idea is that with sufficiently high quality institutions, resources come to good use and improve growth. However, if institutions are below a certain level, the effects of rent-seeking and other non-productive behaviour lead to worse performance. This is shown in Figure 19 below. The regressions a and b show a significant negative correlation between natural resource abundance and growth, but this correlation does not hold for countries with institutions above a certain level, as shown in c. (Mehlum et al., 2006)

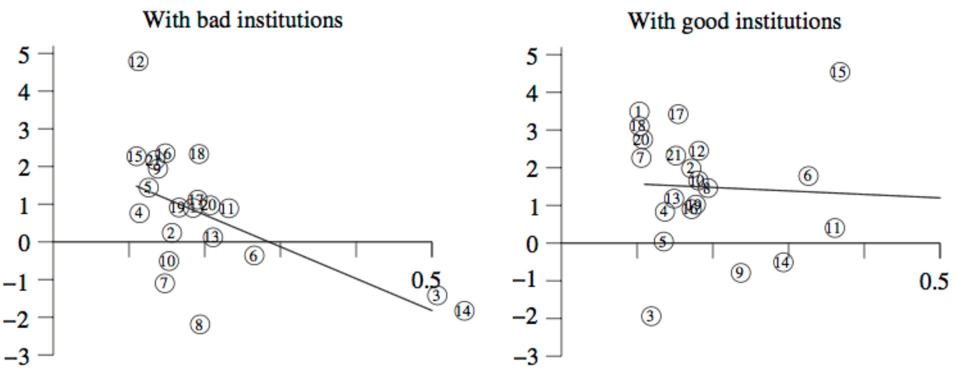

Figure 19. Resource dependence and growth with bad and good institutions.
Source: Mehlum et al. (2006)

Collier and Hoeffler (2005) build on these results and try to identify *which* institutions determine if resource findings have negative effects or not. They suggest that scrutiny is differentially beneficial to economic growth in resource rich democracies. They measure this with the checks index developed by the World Bank's Database of Political Institutions, which describes how many veto instances that the government has to deal with in its policy-making. (Collier & Hoeffler, 2005)

In most societies, there are laws that hinder rent-seeking in the political system. The important difference between a society that resists the resource curse and a society that doesn't is if there is enough scrutiny to deter from rent-seeking behaviour in the administration. The researchers find evidence that scrutiny, including specifically the media as measured by Freedom House's Freedom of the Press index, reduces the effects of the resource curse. A country with a free press does not seem to get any growth penalty, whereas a country with a non-free press seems to. (Collier & Hoeffler, 2005)

The importance of scrutiny is further emphasised by the fact that resource findings tend to undermine scrutiny, meaning that it is important to assess the situation before resources are found. (Collier & Hoeffler, 2005)

5.3 Scrutiny in Greenland

To assess how well prepared the institutions in Greenland are to manage the resource curse, we focus on scrutiny in Greenland. The following section analyses scrutiny within the administrative system. Then follows an analysis of the scrutiny from outside stakeholders, through consultative processes and watchdogs. Finally, the media situation is reviewed and the ability of the media to scrutinise is assessed.

There is little prior work done in this field in Greenland. To this day, only a few studies have been carried out and quantitative data is not available for Greenland in most databases on institutional quality, such as the indices used by Collier and Hoeffler (2005). For the purpose of this study, interviews have been made with representatives from Greenlandic media, politics and society to try to complete the picture.

The following three sections are mainly pointing out areas of improvement. It should be remembered that the comparisons are made with high standards. Generally, Greenland is compared to Denmark, which is a country with high democracy and transparency scores. It should also be remembered that the situation is improving and that the Greenlandic people are learning fast to become more critical towards politicians and authority (Meilvang, 2012 interview). The new government is also reportedly more anxious to avoid corruption claims than the former (NCG, 2012).

5.3.1 Administration

Greenland was considered a colony until 1953, and has since developed at a rapid pace. In the process of developing a modern society, Greenland has to a large extent copied the Danish administrative system. This is a phenomenon that Greenland shares with many other post-colonial societies. Larger economies tend to need a larger and more complex administrative system than smaller economies. The Greenlandic administrative system is, because of the Danish influence, larger and regulated in much more detail than other economies of comparable size. (Dahl, 1986; Karlsson, 2009)

There is a problem of finding educated people in Greenland to support this complex administration. Therefore, Greenland has become very dependent upon Danish civil servants who only work in Greenland for shorter periods. (Dahl, 1986; Karlsson, 2009) This lack of continuity can explain why a small group of experienced high ranking civil servants become very powerful. As they have been in Greenland for a long time, and are well educated, they become key persons within the system.

Greenland is a small state with a small population. This means that there is a risk that personal relationships influence decision making, as everybody knows everybody else. (NBSS, 2011; NCG 2012) Therefore, it is natural that there is a certain amount of nepotism in Greenland (NCG, 2012; Meilvang, 2012 interview). Meilvang (2012, interview) stresses that, since helping each other is a vital part of the Greenlandic culture, it is important to be open around this to avoid negative consequences.

There are examples where employees within the administration have been moved or dismissed for being critical (NCG, 2012). NCG (2012) concludes that there is insufficient protection for whistle-blowers.

The study "Democratic legitimacy in consultation processes associated with large-scale projects in Greenland" (Bjørn Aaen, 2012) discusses how inclusive the government processes are in projects such as hydrocarbon exploration. The conclusion is that the processes both have virtues and shortcomings. On the positive side there is a political will to include the population. The short distances between the politicians and the people, which is a result of the smallness of the nation, is relatively unique for Greenland. On the other hand, the authorities lack transparency and don't make information available proactively to a sufficient extent. This could be improved by e.g. making consultation responses available to the public to a larger extent. (Bjørn Aaen, 2012)

The public sector in Greenland dominates society. It, directly or indirectly, employs a large part of the population, provides housing and is the most important customer for many private enterprises. Additionally, it is involved with companies to compensate them for services that are difficult to run on a market basis. This means that the private enterprises are vulnerable when they criticise the administration. (Meilvang, 2012, interview; NCG, 2012) Meilvang (2012, interview) states that the dependency on the state for employment and housing leads to self-censorship.

Traditionally, the parliament has not been able to fully balance the power of the administration and the government. The parliament audit committee of Greenland has lately assumed its role as a controlling body. However, the national audit only includes financial aspects. Therefore, the parliamentary committees lack management audits to base their decisions on. (NCG, 2012) This makes it hard for the parliament to scrutinise the government.

The language situation also presents an obstacle for scrutiny of the administration (Hendriksen, 2012, interview). Greenlandic is the first language in Greenland, but Danish is still often used, especially in the administration. According to Langgård (2003) there are such differences between ordinary Greenlandic and bureaucratic Greenlandic that many native speakers of the language are unable to understand a parliamentary debate.

5.3.2 Media

Collier and Hoeffler (2005) point specifically to the media as an important institution to scrutinise the government and the administration. They assess the media situation using the Freedom house index *Freedom of the Press*. This index is not available for Greenland. The methodology used by Freedom House includes looking at the press situation from a legal, political and economic perspective (Freedom House, 2012). In the following, those perspectives are used to analyse the Greenlandic media's ability to scrutinise.

Greenland has three nationwide media today. These are the public service radio and television station KNR, and the two newspapers AG and Sermitsiaq. Sermitsiaq and AG had 30 employees together in 2010, and KNR had 108 employees in the same year. (Media Working Group, 2010)

The legal perspective in the Freedom House index includes how well protected press freedom is in law (Freedom House, 2012). The legal framework for media in Greenland is well functioning. Formally, freedom of speech has the same protection in Greenland as in Denmark.

The political perspective in the Freedom House index includes if the media is free in practice, if journalists can operate freely and if information can reach out to the citizens (Freedom House, 2012).

Censorship and intimidation of journalists is not considered a problem by our interviewees (Dollerup Scheibel, Krarup, Egede, 2012, interview) nor is it mentioned in the Media Working Group (2010) report. However, the Media Working Group (2010) states that the government and the political parties have sometimes regarded KNR as part of their communication system and that it is important that the broadcasting company is allowed to work at arm's length from the politicians. Director of KNR, Ivalo Egede (2012, interview), states that it is a problem that the government uses external production companies to produce informational content to be aired on KNR but at the same denies KNR extra funding.

Access to media is widespread in Greenland, and everyone in a representative study watched TV and listened to the radio every day. Additionally, around 9,000 out of 22,000 households in Greenland have access to the internet. Since Greenlandic media is bilingual, while most journalists are only fluent in Danish, translations are needed. Because of a lack of resources, translations are often done hastily. This makes some of them hard to understand. (Media Working Group, 2010)

The economic perspective in the Freedom House index includes how ownership of media is organised, cost of production, sources of income and financial sustainability (Freedom House, 2012). KNR is owned by the government and financed directly through the government budget (Media Working Group, 2010; Egede, 2012 interview). AG and Sermitsiaq are owned by a non-profit foundation (Dollerup Scheibel, 2012 interview).

The financial situation for the media in Greenland is difficult in general. Especially KNR has a problem of making ends meet. KNR broadcasts only around 2 hours of own programs a day, including between 10 and 25 minutes of news depending on how much material they have. The main problem is affording new equipment and to produce programs. The lack of resources means that KNR can only follow up a limited number of stories. E.g., it is not possible to check whether the politicians fulfil their election promises. (Egede, 2012 interview) AG and Sermitsiaq have had economic problems in the past, leading to a merger in 2010. The two newspapers have kept their separate editorial offices but merged all administrative work. (Krarup, 2012, interview)

The result of the economic situation is that the resources are sometimes insufficient to pursue investigative journalism. This is especially a problem considering that the government, the municipalities and the companies today employ journalists as spin-doctors and have stronger editorial offices than the media that is supposed to criticise them. (Krarup, 2012, interview) There is also a lack of educated journalists in Greenland (Media Working Group, 2010).

In conclusion, Greenland has a satisfactory legal framework and political situation for the media. However, the financial situation limits the ability of the media to pursue its scrutinising role. One reason for this might be the smallness of the nation. Media production has considerable economies of scale. Even though KNR receives more funding per citizen than other countries, the total budget is smaller as shown in Table 8.

Table 8. Comparison of yearly budgets for KNR, RÚV, DR and BBC
Source: DR (2011), KNR (2011), BBC (2011), RÚV (2011)

	Yearly budget	Yearly budget/citizen
KNR (Greenland)	65 million DKK	1,142 DKK
RÚV (Iceland)	222 million DKK	700 DKK
DR (Denmark)	3.9 billion DKK	701 DKK
BBC (UK)	42.3 billion DKK	680 DKK

5.4 Institutional Conclusions

This chapter presents Collier & Hoeffler's theory that scrutiny is important to avoid the resource curse. Scrutiny is defined as the ability for internal and external parties to check and influence the government's actions. We perform a qualitative analysis of scrutiny in Greenland with a focus on the administration and on the media.

Generally, scrutiny in Greenland is functioning, particularly considering that the country is a young democracy. The situation is also improving. The main problems related to scrutiny in Greenland are:

- The administration is over-sized and complex which makes it less transparent and susceptible to arbitrariness.
- The lack of continuity caused by the need to import government officials leads to a dependence on key persons within the administration.
- The authorities are not proactive enough in making information available, which makes government processes non-transparent.
- There is no management audit meaning that the politicians lack written accounts to scrutinise the administration.
- Because the public sector is so dominating, companies and individuals are vulnerable when they criticise it, leading to self-censorship.
- The language situation means that it is hard for the public to follow the political debate and the administrative processes.
- Greenlandic media generally lacks the resources to fully scrutinise the administration.
- Both companies and authorities sometimes have PR departments that are stronger than the editorial offices supposed to scrutinise them.
- Politicians do not always respect the independence of the public service television and radio station KNR.

Some of these problems can be attributed to the size of the country and can therefore not easily be overcome. E.g., it is hard to produce high quality bilingual media with a target audience of only 57,000 and personal relationships will always affect decision making and willingness to criticise in small communities. The problems attributed to size may have to be solved or circumvented in new ways since Greenland differs so much from conventional countries in this respect.

Other problems, such as the absence of a management audit and political interference in KNR, are more straightforward to overcome if the political will is there.

Judging by the data collected here, it is not possible to guarantee that Greenland has sufficient scrutiny to avoid the resource curse. Collier & Hoeffler (2005) do not provide a threshold value, they show a correlation. However, the lesson that can be learned is that improvements that can be made should be made. Firstly, because they benefit society even if oil is not found. Secondly, because it is the level of institutional quality present at the point of natural resource discovery that counts since rent-seeking tends to undermine institutional quality. Improving institutional quality is therefore also a way of minimising risk.

The institutional capabilities are especially important for Greenland as the Greenlandic Mineral Resource Fund is be central to control the spending effect. The Faroe Islands example shows what might happen if the Greenlandic Mineral Resource Fund is used irresponsibly. Additionally, the case about Norway emphasises the importance of getting the institutional parameters right to achieve other external effects from the oil industry.

6 Concluding Summary

This thesis investigates how favourable the geological, economic and institutional conditions are for building a self-sustaining economy in Greenland based on its hydrocarbon resources. We show that the geological conditions are favourable, but that the economic and institutional conditions can be improved.

Greenland has been interesting for hydrocarbon exploration before, but the current programme is the biggest yet. The reason for this is that encouraging geological results show a possibility for a working active petroleum system. While the USGS makes hydrocarbon assessment data available, it is not aggregated, making it unsuitable for our analysis. We aggregate this data through a Monte Carlo-simulation.

The geological conditions are encouraging. Table 9 shows that Greenland has a 50% probability of finding at least 29% of Norway's ultimately recoverable resources and a 95% probability of finding at least 8%. This is a significant number considering the size of the Greenlandic population that is only 1% of the Norwegian. We therefore conclude that there are favourable geological conditions to make Greenland self-sustaining. While this aggregated data is still subject to uncertainty, it is more suitable for making predictions about future oil findings in Greenland.

Table 9. Greenlandic resources compared to Norway and the world.
Source: Own calculations based on Gautier (2007), Schenk et al. (2008), Schenk (2010), Gautier (2012, e-mail correspondence), Government of Norway (2012b), Bret-Rouzaut & Favennec (2011), and BP (2011)

	5th percentile	**50th percentile**	**95th percentile**
Greenland's total technically recoverable resources in million barrels of oil	34,695	13,189	3,699
% of Norway's resources	77%	29%	8%
% of world resources	1.2%	0.4%	0.1%
Months of world consumption	13.1 months	5.0 months	1.4 months

We also make a prediction for the total direct government oil income that can be expected. The direct government oil income is determined by the contracts that the Government of Greenland has signed together with the oil companies. As defined there, the Government of Greenland receives a certain percentage of the profits that the oil companies make from production in Greenland. The income is therefore dependent also on the economic viability and time frame of production in Greenland.

In order to determine what the direct government oil income could mean for Greenland, we create four scenarios to model different self-sustaining outcomes. The economy today is heavily reliant on a yearly subsidy from Denmark, the block grant. Achieving a self-sustaining economy would require replacement of the block grant, which is scenario 1. Greenland will also experience rising government expenditure in the future due to demographic changes. Financing this is included in scenario 2. As the economy grows, government expenditure grows. A permanent income increases government income accordingly. This is done in scenario 3. Finally, scenario 4 models a case where the direct government oil income is enough to make Greenland one of the richest countries on Earth.

Table 10. Probabilities for the scenarios (same as Table 6)
Source: Own calculations

	<$50	**$75**	**$100**	**$150**	**$200**
1. Replacing the Block Grant	-	21%	61%	88%	96%
2. Overcoming the Demographic Challenges	-	1%	25%	63%	79%
3. A Permanent Income	-	-	9%	42%	63%
4. The Oil Bonanza	-	-	1%	19%	38%

Table 10 shows the probabilities of the four different scenarios based on the predictions for direct government oil income in our model at different oil prices. At an oil price below $50, production is not economically viable.

We estimate that there is a 61% probability of replacing the block grant with current oil prices. This indicates that it is possible that Greenland can become self-sustaining. However, replacing the block grant will not be enough to keep the government budget balanced assuming current policies. Additionally, the possibility for the oil bonanza is negligible at current oil prices. We therefore conclude that the current optimism surrounding the oil industry is exaggerated.

Large direct government oil income affects an economy through the Dutch disease, which decreases the competitiveness of the exporting industry. We find that Greenland already suffers from Dutch disease and that it is caused by the block grant. An oil economy would probably retain, or aggravate, these effects.

Intuitively, an oil industry should contribute to economic development through job creation, industry formation etc. However, this is not always the case. The explanation is the resource curse. It is therefore important to investigate if and how Greenland can avoid this.

Collier & Hoeffler (2005) find that scrutiny, and especially press freedom, can prevent the curse. There are no prior investigations or indices on the institutional quality in Greenland from this perspective. Therefore, we make a qualitative analysis of this matter through interviews with key officials and a compilation of related publications.

We conclude that scrutiny in Greenland is functioning but that there are some problems left. Our institutional analysis shows that it is impossible to guarantee that the institutional situation is sufficient to avoid the resource curse. The institutional capabilities are especially important as the Greenlandic Mineral Resource Fund will be central to control the spending effect. To manage the fund strictly will therefore be an important task.

7 Recommendations

As we point out in this thesis there are a number of areas regarding hydrocarbons in Greenland that can be improved. Our recommendations for policymakers in Greenland are presented in this chapter. The geological conditions can naturally not be influenced and many of the economic conditions are already decided. There are, however, some economic conditions that can still be influenced. The institutional conditions is the area where most improvements can be made.

7.1 Lower the Expectations

There are high expectations on the oil resources in Greenland today. However, as our results show, it is unlikely that Greenland will end up as an Arctic version of the Middle East. It can be expected that some oil is found, but this will probably not be enough to drastically increase the living standard in a sustainable way. On top of this, there is the risk of increased resource curse effects including aggravation of the Dutch disease that Greenland already has. It is therefore important to try to lower the expectations.

A lot of work is required in order to achieve a self-sustaining economy and it is unlikely that oil will change that. A critical discussion on the prospects for hydrocarbons would perhaps also bring an understanding of how hydrocarbons *can* contribute to economic growth and what this would require from the Greenlandic society. This discussion could therefore benefit society more than either presenting seducing utopian oil visions or saying that the uncertainties are so great that it is better to say nothing at all.

7.2 Lower the Risks

As we have shown in this thesis, oil in Greenland carries a high geological risk that is leveraged through the progressive government take system. For a larger country, this would not be an issue, since the geological risk is not correlated with the overall economy. This is called a diversifiable risk, and is considered unproblematic. In Greenland, however, the income from potential oil findings would constitute such a large part of the economy that the overall economy would become very dependent upon the outcome size of the findings and market factors. This would make the risk of the overall economy correlated with the risk of the direct government oil income, which is the definition of a non-diversifiable risk.

One way to lower this risk is to accept a lower government take in favour of lower risk in the oil project. Most of the instruments that influence the risk are already in place. However, Nunaoil participation in oil production is yet to be decided. Because of the way the Nunaoil participation option is designed, Nunaoil will not be exposed to the geological risk in its decision. However, it will still be exposed to market risks and production cost risks. The Government of Greenland could therefore refrain from investing directly in oil projects through Nunaoil, at least initially.

Another way to lower the non-diversifiable risk is to grow the other parts of the economy, thereby growing the overall economy, and thus lowering the oil share. This could be done by investing in types education that are not only targeted at the oil sector, by growing other industries, such as mining and tourism and furthering entrepreneurship.

7.3 Improve the Institutions

The analysis of institutional quality in Greenland shows a few areas where there are problems. Specifically these were found in the media and in the administration. Some of the problems are due to the smallness of the nation, which limits the market for the media and means that personal relationships will have a larger influence on decision making. There are, however, areas that can be improved. Specifically, the transparency in the administration can be enhanced and steps can be taken to make the public service media less vulnerable to political interference.

The challenges related to the population size can perhaps be tackled through smarter policies. It is important that Greenland does not try to copy the Danish administrative system, but rather that it finds solutions that meet the specific Greenlandic needs. To find out how this can be done, it is important that these issues are discussed.

Focusing on improving institutions is a strategy that carries several benefits. In case oil is found, it will serve to improve the management of the resources. In case less oil is found, it will be a boost to other types of growth and lead to better economic and political decisions. It is therefore a strategy that will bring benefits regardless of the future outcome of the oil sector.

7.4 Be Restrictive with the Fund

The Act on the Greenlandic Mineral Resource Fund is taken in the Greenlandic parliament and this is a good first step to ensure that the direct government oil income will be managed in a responsible way. It is, however, not enough to merely create a fund. The management of it will be the most challenging part, and this can be addressed more clearly already today. Primarily, it should be made clear that the fund is separated from the government budget. The fund should also be used very restrictively in the first years of oil production, before it is clear how large the oil reservoirs are.

When it is possible to make more reliable estimations, a permanent income or such can be constructed. In this way it is possible to avoid a situation where the block grant is abolished, the Dutch disease increases further and the fund is empty, which can be considered a worst case scenario.

If investment on top of the permanent income should be made, deciding how is a difficult decision. Each investment will have to be weighed against the future decreases in permanent income and the Dutch disease effects. A rule of thumb could therefore be to be restrictive with the use of oil money.

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Silis, I. (2012) Author and Photographer, personal interview, 2012-02-06

Sørensen, K. (2012) Former Director at Geological Survey of Denmark and Greenland, personal interview 2012-02-16

Thinghuus, M. (2012) CEO at Royal Greenland, personal interview, 2012-02-27

Appendix 1: Monte Carlo Simulation

A Monte Carlo simulation is a simulation that is run a large number of times using random input variables. If it is run a sufficient number of times, the aggregated outcome of the simulation can be a good proxy for real-world scenarios. In this case, we use a Monte Carlo simulation to determine how the outcome distribution for multiple assessment units in the USGS assessment can be combined into an outcome distribution for all of Greenland.

The Monte Carlo simulation is performed by selecting assessment units to be included, recreating their outcome distribution, running the simulation and then sanity checking the results.

Selection of assessment units

In West Greenland, the assessment units (AU) 2 and 5 and some areas of AU 4 are currently licensed. AU2 and 5 will be included in the simulation, while only half of AU 4 will be included. In East Greenland, AU 1, 2 and 4 will be included, as they overlap with the upcoming licences.

The included AUs are the most promising from the USGS assessment, which might explain why they are chosen for licensing. South Greenland is not included in the simulation due to a lack of data. Since the licences are not allocated through a licensing round, but through an open door policy, it is also likely that they hold less potential.

Re-creation of outcome distributions

The USGS presents its data as the 5th, 50th and 95th percentile and a mean value. In addition, we have the standard deviation of the mean values. This data is presented in Table 1. Since this is all the data currently published by the USGS, we need to re-create an outcome that matches these constraints.

We start with a linear interpolation where P0 = P5 and P100 = P95 = 0. This distribution however overestimates the mean value and underestimates the standard deviation of the distribution of all AUs. Therefore, the distribution will need to be more skewed. We therefore assume that P0 > P5 and introduce a new value exactly between P5 and P50, called P27.5 to our interpolated distribution. We calculate P27.5 as a function of the other variables, such that the mean of the distribution fits the mean given by the USGS and use goal seeking to estimate a P0, that would yield the desired standard deviation of the distribution, while at the same time making sure that the mean value is the same as the USGS mean and that P0 > P5 > P27.5 > P50.

While this exercise seemingly introduces arbitrariness, the results are actually very similar to other methods of approximating the distribution. The reason is the large number of given input variables and constraints in the distribution. This indicates that the re-created distributions are robust.

The re-constructed distributions for each AU are shown in Figure 20, where the x-axis represents the probability space and the y-axis represents the sample space, i.e. total oil findings in million barrels of oil.

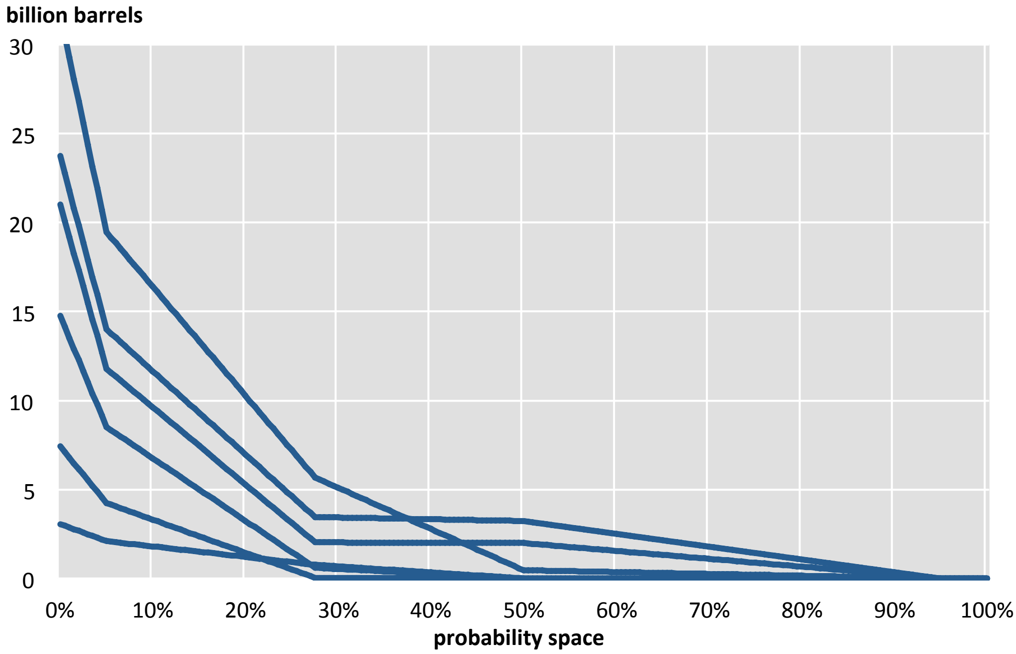

Figure 20. Theoretical outcome distribution of the relevant assessment units.
Source: Own calculations based on Gautier (2007), Schenk et al. (2008), Schenk (2010) and Gautier (2012, e-mail correspondence)

Simulation

The simulation is created as a Python script that outputs the resources in the assessment units in 1000 different simulations.

```
import random
import csv
import datetime

class Assessment_unit(object):

    def __init__(self, name, p0, p5, p50, mean):
        self.name = name
        self.p0, self.p5, self.p50 = float(p0), float(p5), float(p50)
        # Calculate the special P27.5-value
        self.p27_5 = (400 * float(mean) - 10 * p0 - 55 * p5 - 135 * p50) / 90

    def get_size(self):
        x = random.random()
        return self.get_size_at(x)

    def get_size_at(self, x):
        if x <= 0.05:
            return self._interpolate(self.p0, self.p5, 0, 0.05, x)
        elif x <= 0.275:
            return self._interpolate(self.p5, self.p27_5, 0.05, 0.275, x)
        elif x <= 0.5:
            return self._interpolate(self.p27_5, self.p50, 0.275, 0.5, x)
        elif x < 0.95:
            return self._interpolate(self.p50, 0, 0.5, 0.95, x)
        else:
            return 0

    def _interpolate(self, y_min, y_max, x_min, x_max, x):
        return (x - x_min) / (x_max - x_min) * (y_max - y_min) + y_min

# Set up simulation
number_of_runs = 1000

# Set up assessment units
assessment_units = []
assessment_units.append(Assessment_unit("West AU 2",      31729,    19465,  464, 4903 ))
assessment_units.append(Assessment_unit("West AU 5",      14771,     8514,    0, 1675 ))
assessment_units.append(Assessment_unit("West AU 4 (50%)", 7431,     4285,    0, 777.5))
assessment_units.append(Assessment_unit("East AU 1",      21019,    11793, 1989, 3274 ))
assessment_units.append(Assessment_unit("East AU 2",      23745,    13996, 3228, 4384 ))
assessment_units.append(Assessment_unit("East AU 4",       3062,     2095,    0,  537 ))

# Run simulation
au_sizes = [[au.get_size() for i in xrange(number_of_runs)] for au in assessment_units]

# Save output to CSV
writer = csv.writer(open('mc-output.csv', 'wb'))
writer.writerow(["Generated {0}".format(datetime.datetime.now().strftime("%Y-%m-%d
%H:%M"))])
writer.writerow([" "])
writer.writerow(["Output"])
writer.writerow([au.name for au in assessment_units])
writer.writerows(zip(*au_sizes))
```

Sanity check

Table 11 presents the mean value and sum of the standard deviations in all AUs in our run of the simulation

Table 11. Differences between simulation output and the USGS data
Source: Own calculations based on Gautier (2007), Schenk et al. (2008), Schenk (2010) and Gautier (2012, e-mail correspondence)

	Sum of means	Sum of SDs
From simulation	15,664	21,451
From the USGS	15,551	21,963
Difference	**+0.73%**	**-2.33%**

The differences are quite small, indicating that this data is a good approximation. For increased accuracy, the simulation could have been run e.g. 10,000 times, but this would only have produced slightly more accurate data, while increasing the data processing needs tenfold.

Appendix 2: Government take

The surplus royalty system that is described in the model licences (BMP, 2004b, 2006b, 2007b, 2009b, 2009c) is somewhat complex. It consists of three separate surplus royalties amounting to 7,5%, 10% and 12,5% of the profit respectively. The theoretical maximum royalty payable is therefore 30%. It is, however, only payable after certain profitability is met since losses from past years can be carried forward and increased by different percentages for the three different surpluses. To determine the exact effective royalty rate, a comprehensive investment calculation has to be performed where revenues and costs are calculated on a year-to-year-basis. The Bureau of Minerals and Petroleum has together with PricewaterhouseCoopers performed a number of such calculations over the years, but while the results are made public, the underlying calculations have been kept confidential.

One such calculation (PwC, 2010) calculates the effective surplus royalty rates for a 500, a 1,000 and a 2,000 million barrels of oil production site and estimates the effective surplus royalty rates to 15%, 22% and 27% respectively. The size of the fixed costs in an oil production, which is high in the smaller fields and low in the larger fields, has the largest impact on the effective royalty rate. Similarly, a high oil price in relation to the cost would yield a higher effective royalty rate.

As noted above, the surplus royalty will probably be higher for larger fields and lower for smaller fields. Since the sizes of the accumulations in the model are unknown, only the oil price will be accounted for, and is mapped to the effective royalty rates from the Bureau of Minerals and Petroleum/PWC calculations in Table 12.

Table 12. Mapping effective surplus royalties to oil price levels.
Source: Own calculations. MMBO = million barrels of oil

Oil price	Gross profit per barrel	Corresponding BMP scenario	Effective surplus royalty
$200	$150	2,000 MMBO	27%
$150	$100	2,000 MMBO	27%
$100	$50	1,000 MMBO	22%
$75	$25	500 MMBO	15%

Appendix 3: Net Present Value of the Scenarios

The net present value of these scenarios are calculated as if the scenarios would start at year-end 2011. This is a simplification, as, in reality, the mineral resource fund can not be used until there is money in the fund. It still, however, provides a reasonable approximation of the costs of the scenarios.

As described in section 4.6.2 the block grant will decrease as revenue from mineral resources starts to appear. This is calculated as the revenue flowing into the fund, not the income to the government. In the scenarios below, the revenue will have to be so large, that the block grant will disappear entirely. Therefore, the block grant will not be included as an alternative cost in these calculations.

The Block Grant

The yearly transfers of money from Denmark to Greenland are in the form of a block grant. On top of this, the Danish state still finances a few areas of responsibility in Greenland such as the judicial system and the police. The value of these services can be estimated and added to the block grant. In 2012 the block grant is 3,533 million DKK (Greenlandic Economic Council, 2011). The expenditures for the areas of responsibility were 747 million DKK in 2009 (Statistics Greenland, 2011b). Assuming that these have followed the Danish inflation of around 2% these expenditures are 793 million DKK in 2012. The block grant including Danish state expenditure is thus 4,326 million DKK in 2012.

The net present value of the block grant can be modelled as a perpetuity that is fixed in real terms. The real return on the oil fund, i, calculated in section 4.1.7 to be 2%, is used as the discount rate. This gives a net present value of the block grant of:

$$\frac{4326}{2\%} = 216 \text{ billion DKK}$$

The Deficit

The stagnation in government income relative to spending will show up in the budget from around 2015 and will lead to increasingly large budget deficits up to at least 2030 assuming current spending policies. (Greenlandic Economic Council, 2011; Tax and Welfare Commission, 2011)

One possibility of solving this is by using direct government oil income. In order to compare this financial challenge with the oil income, the net present value of the prognosticated deficits is calculated.

The yearly budget deficit is estimated to start in 2016 and grow until 2035. From 2036 and forward, as the dependency ratio flattens out, it is estimated to be 15% of GDP and grow with the economy, based on estimates from the Greenlandic Economic Council (2011).

This is modelled as a growing annuity starting at 200 million DKK in 2015 and growing with 15,9% per year in 20 years, reaching 15% of the GDP in 2035. While this growing annuity is a rough estimation, this has a very small impact on the overall net present value. From 2036 and forward it is modelled as a perpetuity growing with the overall economy, starting at a value of 3,306 million DKK, which corresponds to 15% of GDP in 2035, provided that the Greenlandic economy maintains its yearly GDP growth at about 1%.

The net present value of the growing annuity is:

$$\frac{\frac{200}{2\%-15.9\%}*\left[1-\left(\frac{1+15.9\%}{1+2\%}\right)^{20}\right]}{\left(1+2\%\right)^{4}}=15{,}782 \text{ million DKK}$$

The net present value of the perpetuity is:

$$\frac{\frac{3306}{2\%-1\%}}{(1+2\%)^{24}}=205{,}516 \text{ million DKK}$$

The total net present value of the budget deficit is thus 221 billion DKK

A Permanent Income

To determine a permanent income, a long-term real GDP growth rate, g, is assumed. The historic average real GDP growth rate 1979 - 2011 has been 1.5%. However, the average GDP/capita growth has only been 1.0%. The difference between the measurements is because of a small population increase, which took part mostly before 1990. As the population has stopped growing, it is assumed that the GDP growth will follow the historic GDP/capita growth rate, i.e. 1%. This is consistent with the assumptions used in both the Greenlandic Economic Council (2011) and the Tax and Welfare Commission (2011).

The permanent income block grant is modelled as a growing perpetuity. The net present value of this perpetuity is calculated by dividing the initial block grant with the difference between the return of the fund and the GDP growth. Its value is:

$$\frac{4326}{(2\% - 1\%)} = 433 \text{ billion DKK}$$

Creating the scenarios

These components are combined in different ways to create the four scenarios, as can be seen in Table 13.

Table 13. Scenario cost calculations
Source: Own calculations

Scenario	Funding requirement			Total
	Block grant	Deficit	Permanent income	
1. Replacing the Block Grant	216			**216**
2. Overcoming the Demographic Challenges	216	221		**438**
3. A Permanent Income		221	433	**654**
4. The Oil Bonanza		221	2 * 433	**1086**

Appendix 4: Price comparisons

There are two studies of the price level difference between Greenland and Denmark. They are made by Paldam (1994) and Statistics Greenland (1994) and show very similar results. Paldam calculates consumer prices with both Greenlandic and Danish weights and estimates that the average consumer price level in Greenland is 23,1% higher than in Denmark for January 1994. Statistics Greenland calculates both consumer prices and GDP price levels using both Greenlandic and Danish weights and estimates that the average consumer price level is 25% higher and the average GDP price level is 18% higher in Greenland than in Denmark in the same year. These results are extraordinary, considering that Denmark has a 25% VAT whereas Greenland does not have any VAT at all. With the VAT subtracted from the Danish prices, the price difference is around 50%. Even if transport costs and the Greenlandic climate can account for some of that difference, it is clear that prices are still excessively high. (Paldam, 1994)

Unfortunately, no price comparisons have been carried out since 1994, so, to test whether these price differences still are present, we use the 1994 studies as a reference point and the differences in the Danish and Greenlandic consumer price indices (CPI) as an approximation. While this has the drawback that the consumer price indices are calculated using somewhat different goods, it is the best approximation that can be made given the data available.

In this method, CPI series for Greenland and Denmark are collected and converted to use 1994 as the base year. In 1994 the price level in Greenland is approximated to be 24,05% higher than in Denmark, the average of the two studies from that year. The price difference, i.e. how much more expensive it is in Greenland, for each year can then be calculated as:

$$\frac{CPI^{94}_{Denmark} * 1,2405}{CPI^{94}_{Greenland}} - 1$$