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Preface

The purpose of this report is to measure Norwegian raw oil and natural gas wealth, primarily based on annual national accounts data, with the view to standardize the measurement methodology and data collection, and to incorporate the estimates of oil and gas wealth into the Norwegian balance sheets accounts on a regular basis. The work will lay down a solid foundation for the construction of harmonized asset accounts in the long run that are simultaneously of both physical and monetary dimensions, as suggested by the latest SEEA.

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Statistics Norway, 30 November 2016.

Christine Meyer

Abstract

Based mainly on national accounts statistics, and supplemented with experts' prediction about the expected profiles of production and price for raw oil, natural gas and the LNG, this paper makes estimation of the Norwegian oil and gas wealth for the period 1970-2015, by means of the NPV approach, as recommended by the latest SEEA. The estimated results demonstrate that in per capita terms, the Norwegian oil and gas wealth in constant (2015) prices has already passed its peak around 2000 and now is decreasing, which signals unsustainability if merely oil and gas are concerned. However, since a large part of the resource rents from extracting oil and gas are invested into other types of assets through the GPFG, it may not be so worrisome in terms of sustainability.

Sammendrag

Med utgangspunkt i nasjonalregnskapsstatistikk, i tillegg til eksperters prognoser om produksjonsnivå og pris på olje, naturgass og LNG, foretas det i denne rapporten estimering av norsk olje- og gassformue i perioden 1970-2015. Det er brukt en NPV-tilnærming, som er anbefalt i den nyeste SEEA. De estimerte resultatene, målt per innbygger i faste 2015-priser, viser at norsk olje- og gassformue allerede har passert sitt toppunkt rundt år 2000 og er nå avtagende. Dette signaliserer en lite bærekraftig utvikling når olje og gass betraktes isolert sett. Dersom det imidlertid tas i betraktning at ressursrenten fra utvinning av olje og gass er investert i andre typer kapital i SPU, vil ikke utviklingen være like bekymringsfull sett i lys av bærekraft.

Contents

1. Introduction

Extraction of oil and gas plays an important role in the Norwegian economy, and the direct contribution to GDP had been nearly 20 per cent on average the last 15 years. The contribution to GDP increased gradually during the 1970s and reached 16 percent in 1985. After a period of small decline (about 10 per cent) through to the mid-1990s, the share picked up again. The same pattern can be observed when analyzing the export of oil and gas as a share of total exports. It reached about 35% around the late 1990s. From 2000 up to date, Norwegian export of raw oil and natural gas has accounted for more than 45% of its total export. [1]

Besides the direct contribution by way of export to the GDP, the Norwegian offshore industry extracting raw oil and natural gas has also generated substantial demand for goods and services that are produced by other industries located in the mainland-Norway[2], thus contributing indirectly but significantly to the overall economic growth in Norway (see e.g. Cappelen *et al*., 2013).

Faced with the booming oil and gas industry, in order to secure sustainable development for future generations, the Norwegian government introduced in 2001 the budgetary rule, stipulating that government income (through tax and other direct involvements) from oil and gas go directly into the Government Pension Fund Global (GPFG) [3], from which only a maximum of 4% of the fund's value can be allocated to the government budget each year (Norwegian Ministry of Finance, 2000).[4]

With the 4% rule, how much annual income derived from extracting oil and gas can be used for financing public expenditure will depend on the total accumulated value of the GPFG fund, and fundamentally, it will depend on how large the wealth of Norwegian raw oil and natural gas will be. Thus, a good measure of such wealth is of significant importance for a better management, as well as its sustainability, of public finance.

In the System of National Accounts (SNA), oil and gas as typical non-renewable resources are classified as part of Mineral and energy reserves (AN212), which themselves are part of Natural resources (AN21) (see e.g. United Nations, 2009; Eurostat, 2013). Further, oil and gas are not only valuable resources worth being registered in the balance sheet accounts in the SNA;[5] but also notoriously, they are fossil fuels, the use of which in economic activities is bound to generate greenhouse gas emissions, leading to the conundrum of global warming.

To address the pending global issue, and more importantly, to facilitate reaching environmental as well as economical sustainability, a good accounting of raw oil and natural gas, not only in terms of physical quantities, but also of economic values; both in terms of their uses (flows), and of their reserves (stocks), is

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[1] The only exception during this period (from 2000 to the present) is in 2015 when raw oil and natural gas accounted for 39% of the total export in Norway.

[2] The mainland-Norway (*Fastlands-Norge* in Norwegian) refers to all Norwegian industries excluding the offshore industry extracting oil and gas, and pipeline transport of oil and gas, as well as maritime transport.

[3] The Government Pension Fund Global (*Statens Pensjonsfond Utland* in Norwegian) was previously called the Government Oil Fund (*Statens Petroleumsfond* in Norwegian), and now is one part of the total Norwegian Government Pension Fund, of which the other part is the Government Pension Fund Norway (*Folketrygdfondet* in Norwegian).

[4] The 4% set by Norwegian Ministry of Finance refers to an expected long-term real rate of return to the GPFG (see e.g. Norwegian Ministry of Finance, 2012).

[5] In the balance sheets of the current Norwegian annual national accounts, the estimate for Mineral and energy reserves (AN212) has been missing.

indispensable. This is exactly the advocated purpose for compiling the System of Environmental-Economic Accounts (SEEA) (United Nations, 2013).
Measuring Norwegian oil and gas wealth has been carried out in several occasions. However, not until recently, neither regularly, the measuring work was undertaken, mostly within the framework of national wealth accounting, at both Statistics Norway and Norwegian Ministry of Finance (e.g. Brekke et al., 1989; Aslaksen *et al*., 1990; Lindholt, 2000; Greaker *et al*., 2005; Norwegian Ministry of Finance, 2012), although in Norway, accounting for natural resources including oil and gas has a long history ever since 1970s.[6]

Within Statistics Norway, there has been a need for updating both the methodology and data sources applied for measuring national wealth in general, and its components including oil and gas in particular, since the last important report was published more than ten years ago (Greaker *et al*., 2005)[7]. During the years, the empirical estimation results were updated at times by simply using new years' data, the methodology applied, however, has no major changes (e.g. Brunvoll *et al*., 2012).

On the international arena, a call for an integration of environmental and economic accounting work has been repeatedly voiced by the academia, policy-makers, the media and the public more generally. In recognition of the long history and the experiences gained from compiling the accounts for natural resources including oil and gas in Norway, further advancement in research along this line is very much encouraged.

The purpose of this paper is to measure Norwegian raw oil and natural gas wealth, primarily based on annual national accounts data, with the view to standardize the measurement methodology and data collection, and to incorporate the estimates of oil and gas wealth into the Norwegian balance sheets accounts on a regular basis.[8]

The work will lay down a solid foundation that makes it possible for further integration of the economic accounts (from national accounts within the SNA) and the physical accounts (from natural resource accounts that have been compiled for many years at Statistics Norway), in order to generate harmonized asset accounts in the long run that are simultaneously of both physical and monetary dimensions, as suggested by the SEEA (United Nations, 2013).

By means of an experts' prediction about the future production and price profiles of Norwegian raw oil and natural gas, the streams of resource rents that are generated from extracting raw oil and natural gas are calculated. Following the recommendations by the latest SEEA (United Nations, 2013), the Net Present Value (NPV) approach is then applied to yield the final estimates for Norwegian oil and gas wealth covering the period 1970 - 2015.

The rest of the paper is structured as follows: Section 2 introduces briefly the definition of resource rent and discusses in detail the NPV approach that is applied for measuring Norwegian oil and gas wealth. In Section 3, empirical methods for estimating resource rent are investigated in terms of their strengths and weaknesses, in both theoretical and practical perspectives.

[6] For a brief overview on wealth accounting practices and its relationship with the work for natural resource accounting in Norway, see Liu (2013).

[7] In Greaker *et al*. (2005), Norwegian national wealth, including the oil and gas component, was estimated for the period of 1985-2004.

[8] Note that reporting to Eurostat the estimates for natural resources in general, and for oil and gas in particular, is still on a voluntary basis (see Eurostat, 2014).

Also in Section 3, by applying the recommended residual value method for estimating resource rent, and based on practical assumptions, the empirical estimation results of the actual and expected resource rents generated from the industry extracting oil and gas are presented. Based on estimated resource rents, the final results of Norwegian oil and gas wealth in the period 1970-2015 are estimated and briefly discussed. Finally, some concluding remarks with suggestions for future work are made in Section 4.

2. Methodology

While important inputs that are comprehensively used in various production activities in today's modern economy, oil and gas are themselves regarded as one type of non-produced assets. This implies that they come into existence by nature, in other words, in ways other than through process of production that is defined in the SNA (see e.g. United Nations, 2009; Eurostat, 2013). Their valuation is thus different from that for conventional produced assets.

For many types of produced assets (such as buildings and machines), their market transaction prices (of either new or used assets) are relatively easier to observe, and so can be directly used for valuation; if market prices are not available, the written-down replacement costs or even their production costs can also be applied for making estimates of their market value. However, it is not the case for oil and gas.[9]

For oil and gas, it is very seldom, if not impossible, to obtain the market transaction prices for the oil and gas *in situ*, which is a stock concept, although the buying and selling information for extracted oil and gas, which is a flow concept, are usually available. Nonetheless, the latter information (flow) can well be used for making estimation of the value of the former (stock), by means of the NPV approach.

The NPV approach, also commonly referred to as the discounted value of future returns approach, uses projections of the future rate of extraction of the asset (here oil and gas), together with projections of its price, to generate a time series of expected returns. With the assumption that returns earned in the current period are worth more to the extractor than returns earned in the future, the stream of expected returns is discounted to reflect the value that a buyer would be prepared to pay for the asset in the current period (United Nations, 2013).

For natural resources such as oil and gas, the returns are usually defined by using the concept of resource rent, which is best considered to be the surplus value accruing to the extractor or user of a natural resource, calculated after all costs and normal returns have been taken into account (e.g. United Nations, 2009, 2013; Eurostat, 2013).

Formally, for making estimate of the value of an asset by applying the NPV approach, we have the following equation:

(1)
$$V_t = \sum_{\tau=0}^{T_t} \frac{NR_{t+\tau}}{(1+\delta_t)^{\tau}} ,$$

where

V_t = value of the asset at time t;

T_t = remaining asset life at time t;

[9] Although for some non-produced assets, such as a piece of land, the market transaction information may sometimes exist.

$NR_{t+\tau}$ = nominal resource rent at time $t+\tau$, τ = 0, 1, 2…T_t ;

δ_t = nominal discount rate at time t.

Suppose the nominal resource rent $NR_{t+\tau}$ evolves in line with an expected general rate of inflation, then we have

(2) $$NR_{t+\tau} = RR_{t+\tau}(1+\rho_t)^{\tau} ,$$

where

$RR_{t+\tau}$ = real resource rent at time $t+\tau$, τ = 0, 1, 2…T_t ;

ρ_t = expected general rate of inflation at time t.

Inserting equation (2) into equation (1) and reorganizing it yields:

(3) $$V_t = \sum_{\tau=0}^{T_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}} ,$$

where

r_t = real discount rate at time t and is defined as:

(4) $$r_t = \frac{1+\delta_t}{1+\rho_t} - 1 .$$

Clearly, the logic of the NPV approach requires estimating the stream of resource rents that are expected to be earned in the future and then discounting these resource rents back to the present accounting period. This provides an estimate of the value of the asset based on the information set acquired at that point in time. Thus, as departure, the resource rent has to be estimated before applying the NPV approach to measure the value of an asset (here oil and gas).

3. Empirical results

3.1. Approaches to measuring resource rent

There are three main approaches to measuring resource rent in practice: the appropriation method, the access price method and the residual value method.

The appropriation method estimates resource rent using the actual payments made to owners of natural resources. In many countries, governments are the legal owners of oil and gas on behalf of the country at large. As legal owners, the governments could in theory collect the entire resource rent derived from extraction of the resources that they own, through mechanisms such as fees, taxes and royalties.[10]

The advantage associated with the appropriation method is that the required data are readily available from government accounts, which are in general of good

[10] A similar method for calculating resource rent from extracting oil and gas was applied by the Norwegian Ministry of Finance when preparing annual national budget in Norway (e.g. Norwegian Ministry of Finance, 2016).

quality in a country. But the disadvantage is that in practice, the fees, taxes and royalties actually collected may tend to understate total resource rent, as the rates may be set with other priorities in mind, for example, encouraging investment and employment in extracting industries.

The access price method is based on the fact that access to resources may be controlled through the purchase of licenses and quotas. When these resource access rights are freely traded, so that the rights themselves (in whatever forms, such as written contracts and/or issued licenses) become a type of asset. Thus, it is possible to estimate the value of the relevant resource rents from the transacted market prices of the rights/asset.[11]

While theoretically appealing, however, in practice and in many cases governments may give the access rights direct to extractors for free or do so at a price that is less than the true market value. Further, trading of the rights may be restricted or prohibited. Under such circumstances, there may be no directly observable market valuation.

The residual value method is the most commonly applied method. Under this method, resource rent is estimated by deducting user costs of produced assets from gross operating surplus after adjustment for any specific subsidies and taxes, by means of national accounts statistics for the production unit extracting natural resources.

In principle, all of the above-mentioned three methods will generate the same estimates of resource rent, given the equivalence of the economic reasoning behind. For example, the economic logic behind the access price method parallels that for the residual value method, because it is expected that, in a free market, the value of the total rights should be equivalent to the future returns from the asset in concern (after deducting all costs, including user costs of produced assets).

However, in reality the application of either the appropriation method or the access price method is more heavily influenced by institutional arrangements in a specific country. For these reasons, it is suggested that estimates of resource rent based on the residual value method by applying national accounts statistics should be compiled where appropriate (see United Nations, 2013).

The residual value method can be implemented by following the steps as listed in Table 3.1 as recommended by the SEEA (United Nations, 2013). In Table 3.1, almost all items used for deriving the resource rent can be directly drawn from national accounts datasets. However, one should take note that to the gross operating surplus on the basis of the SNA framework, product specific taxes should be added, while product specific subsidies deducted, in order to reach the gross operating surplus before the derivation of resource rent.

The reason is that the output as shown in Table 3.1 is valued in basic prices, which excludes taxes while includes subsidies on products. However, product specific taxes on natural resource extraction are regarded as part of the resource rent that is generated due to the extraction, and thus should be included into the resource rent; while product specific subsidies are usually considered to be part of the cost that is involved with the extraction, and therefore, should be deducted accordingly.

[11] In some cases, where the access rights allow a very long or even indefinite access to the resource, the market value of the access rights could provide a direct estimate of the total value of the resource in concern.

Table 3.1. Deriving resource rent from the SNA measures

Output (sales of extracted environmental assets at basic prices, includes all subsidies on products, excludes taxes on products)
Less Operating costs
Intermediate consumption (input costs of goods and services at purchasers' prices including taxes on products)
Compensation of employees (input costs for labor)
Other taxes on production plus other subsidies on production
***Equals* Gross operating surplus—SNA basis**
Less Specific subsidies on extraction
Plus Specific taxes on extraction
***Equals* Gross operating surplus—for the derivation of resource rent**
Less User costs of produced assets
Consumption of fixed capital (depreciation) + return to produced assets
***Equals* Resource rent**
Depletion + net return to environmental assets

Source: United Nations (2013)

As for other taxes (net of subsidies) on production (rather than on products) that are imposed on producers and are independent on the amount of production (such as taxes on land or premises used in production, or taxes on the labor force employed), they are already excluded from the resource rent calculation through deducting operating costs as shown in Table 3.1.

Another popular tax imposed on the industry extracting natural resources is usually levied on the profit of the industry. Therefore, it should be considered as redistribution of resource rent and thus pure transfer between the government and the industry. This redistribution has no impact on the total amount of resource rent from extracting natural resources, and should not be taken into consideration when following the calculation steps of the resource rent as listed in Table 3.1.

Ideally, the resource rent should be calculated for each different natural resource, such as for raw oil and natural gas respectively. However, within the Norwegian national accounts datasets, it is hard to partition the operating surplus of the whole industry extracting raw oil and natural gas into particular extraction activity related only to raw oil (or natural gas) individually.

The reason is that although information on the production of either oil or gas is available, the partitioning of production inputs, such as the required intermediate consumption, labor and produced capital, is not straightforward. For instance, for some Norwegian petroleum fields, it is almost impossible to separate costs related to oil extraction from those related to gas extraction. Therefore, in this paper, the resource rent from extracting Norwegian oil and gas is calculated as a whole for oil and gas, rather than for each individual resource, i.e. oil and gas separately.

3.2. Actual resource rent (1970-2015)

In this paper actual resource rent refers to the resource rent that was realized in the past as well as the current year (1970-2015). Except for the return to produced assets, almost all the items needed for calculating the actual resource rent (see Table 3.1) for this period of time are available in the StatBank at Statistics Norway, and can be directly applied for the computation. [12]

In Norway, there are common *other taxes and subsidies on production* (such as taxes on automobiles owned), but no product specific taxes/subsidies related to the oil and gas extracting industry. However, there does exist one special tax which is

[12] National accounts data for 2014 and 2015 as shown in StatBank Norway are preliminary numbers and so have to be revised later, while for the other years (1970-2013), the relevant data are final.

levied on the profit of the oil and gas extracting industry. The special tax rate is 53% in 2016, on top of the ordinary income tax (25%) for other industries.[13] As mentioned, since this special tax has no impact on the total amount of resource rent generated, it is ignored for the calculation of the resource rent in the following.

Conventionally, the return to produced assets that are employed in a specific industry is calculated as a residual, by deducting consumption of fixed capital from the gross operating surplus in that industry. However, if calculated simply as such, the return to produced assets for the Norwegian offshore industry extracting oil and gas is particularly high, due apparently to its inclusion of the resource rent.

Note that one common feature in the definition of resource rent is that the amount of resource rent is always derived relative to the returns earned by other firms on average over time, i.e., normal return.[14] Thus the key is to find a 'normal' return which can be expected from owning the produced capital employed in the industry extracting oil and gas.

In this paper, the normal return is defined in each year as the net operating surplus divided by the net stock of produced assets in the mainland-Norway (*Fastlands-Norge* in Norwegian) for that year. The data for net operating surplus and net stock of produced assets in the mainland-Norway can be directly drawn from annual Norwegian national accounts datasets.

When applying the above definition in practice, some cautions should be taken. First, there may exist several factors leading to an upward-biased estimate of the normal return to produced assets. For example, without correctly pricing a number of production inputs (such as rinsing, absorbing capacity of the nature) coming from the environment within which various economic activities occur, the net operating surplus for those industries dumping pollution to the environment is mistakenly high.

Another example is that in Norway, some self-employed persons managing their own household enterprises may prefer not to take out their wages/salaries. On the contrary, they prefer to put them as the dividends or profits instead (e.g. Fjærli and Lund, 2001), resulting to an upward-biased estimate of the net operating surplus.

Certainly, the calculated normal return to produced assets also includes other resource rents, such as those from fish farming industry, forestry industry, etc. However, compared with the specific industry extracting oil and gas, the resource rents from other Norwegian natural resource industries are considered to be so small that it gains little by grappling with taking them out from the calculated normal return by using the above-mentioned definition (Greaker et al., 2005).

Ideally, all these factors leading to an upward-biased estimate of the normal return should be addressed in a proper way. However, due to both conceptual, methodological and data difficulties, the necessary adjustments were not made for the moment, and may be left as a topic for future research.

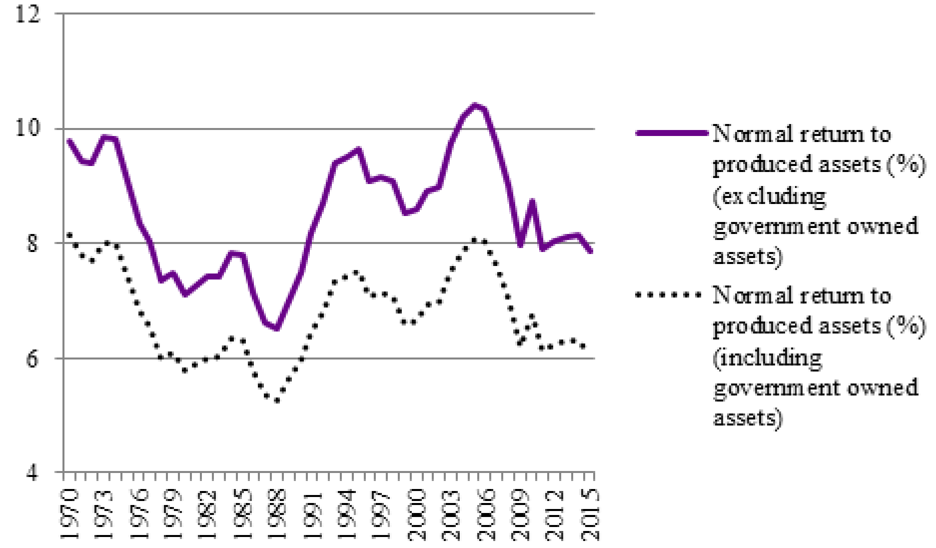
On the other hand, there may also exist some factors leading to a downward-biased estimate of the normal return to produced assets for the mainland-Norway, if directly using the above-mentioned definition for the normal return calculation. For instance, the net operating surplus to produced assets owned by general

[13] Therefore, the total income tax rate for the industry extracting oil and gas in Norway is 78% in 2016.

[14] Resource rent itself, as a residual, may be positive or negative. Economic theory suggests that, over the long term, resource rents should be positive.

government (including central and local governments) is set by convention equal to zero in the current Norwegian annual national accounts, in accordance with international recommendations in 2008 SNA and ESA 2010.

Figure 3.1. Annual normal return to produced assets (1970-2015) (%)



Source: Author's calculation based on data from StatBank Norway

As clearly shown in Figure 3.1, without excluding the produced assets that are owned by general government (including central and local governments) from the total net stock of produced assets in the mainland-Norway, the corresponding estimate of the normal return will be downward-biased.

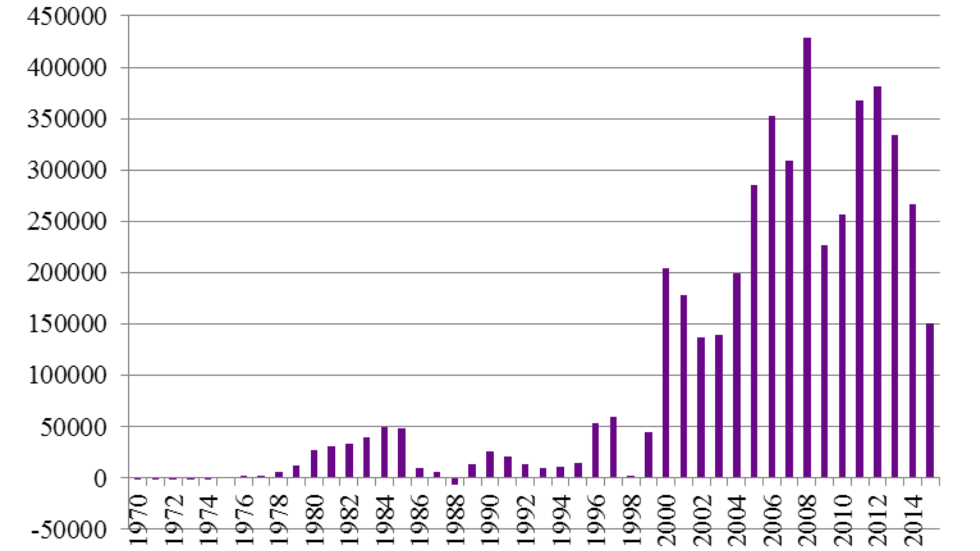
Consequently, in this paper, the normal return to produced capital is finally calculated by excluding the produced assets that are owned by general government (including central and local governments) from the total net stock of produced assets in the mainland-Norway. This normal return is thus applied for calculating the resource rent for the industry extracting oil and gas. This way to deriving the normal return is different from what was applied in Greaker *et al*. (2005).

Another difference between this paper and Greaker *et al*. (2005) is that in the latter, the labour inputs for the oil and gas extracting industry is calculated as the multiplication of an average wages/salaries rate for the mainland-Norway and the total actual working hours in the industry extracting oil and gas; while in this paper, it is the actually observed labour input costs in the industry extracting oil and gas that are used for calculating the resource rent, following the steps in Table

The argument in Greaker *et al*. (2005) by using the calculated, rather than the actually observed, labour input costs is that the observed wages/salaries are considered to be especially and abnormally high for the Norwegian oil and gas extracting industry, possibly due to that the high operating surplus (including resource rents) in the industry gives rise to more room for the negotiation of wages/salaries between the labour union and the employers.

This argument may make certain sense. However, being the value of labour contributing to the production process, labour input costs (compensation of employees) reflect a kind of 'capital services' generated by human capital embodied in those employees working in the oil and gas industry. Because specific knowledge are needed for working in this industry, it might be more reasonable to consider the high wages/salaries as simply to reflect the market value of the special knowledge embodied.[15]

Figure 3.2. Actual resource rent from oil and gas (current prices, NOK millions)



Source: Author's calculation based on data from StatBank Norway

With the estimated normal return, and other statistics that are directly drawn from annual Norwegian national accounts datasets, following the steps as listed in Table 3.1, the actual nominal resource rents for the period 1970-2015 from the Norwegian industry extracting raw oil and natural gas can be derived and are presented in Figure 3.2.

3.3. Expected resource rent (2016-2085)

To calculate the expected resource rent from 2016 onwards, one should have the information on the expected profiles for extraction, price and various costs for the industry extracting oil and gas. The expected production profiles for Norwegian raw oil, natural gas and liquefied natural gas (LNG) from 2016 up to 2085 are directly obtained from data inputs prepared for the Norwegian *National Budget 2016* (Norwegian Ministry of Finance, 2015). They are displayed in Figure 3.3 (see Table A1 in Appendix for detailed figures).

Note that the expected production profiles for Norwegian raw oil, natural gas and LNG from 2016 up to 2085 are originally based on experts' assessments from the Norwegian Petroleum Directorate (NPD), with the implicit assumption that all discovered reserves as registered in the NPD resource accounts will be extracted up in the end.[16]

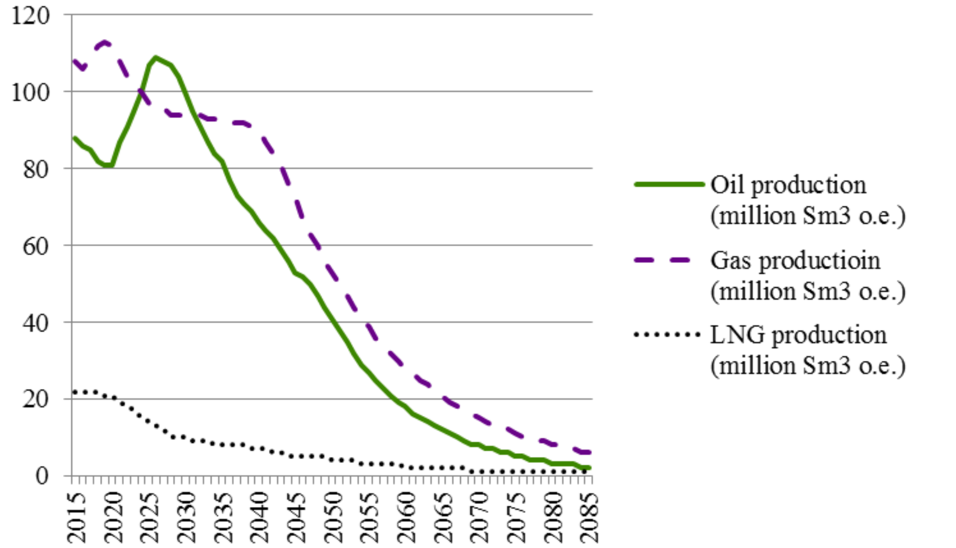
The expected price profiles for Norwegian raw oil, natural gas and the LNG from 2016 up to 2085 are either directly drawn from, or indirectly calculated based on, the relevant assumptions that were made in the *National Budget 2016* [17] (Norwegian Ministry of Finance, 2015).

[15] This view is also in accordance with the way human capital is calculated by means of the lifetime-income approach (see e.g. Liu, 2014).

[16] Although not all such resources are currently considered as commercially extractable.

[17] Nasjonalbudsjettet 2016 in Norwegian. See Page 28, and Table 2.4 on Page 31, for detailed information.

Figure 3.3. Expected production profiles for raw oil and natural gas (2015-2085)



Source: Norwegian Ministry of Finance (2015)

According to the national budget, the current prices for raw oil per barrel are assumed to be NOK 440 and NOK 474 in 2016 and 2017, respectively. [18] For oil prices in the future, i.e. from 2018 onwards, this paper will make some simple calculations by using the same assumption as applied by the national budget, which is originally derived from the Norwegian *Economic Outlook 2013* [19] (Norwegian Ministry of Finance, 2012).

The assumption is based on the view that in the long run the global demand for raw oil will increase from the low level as being observed currently, though in a lower tempo than before. In order to meet the increasing oil demand, and given the decreasing production from the current oil fields, only a higher oil price can lead to new investments in the global oil production capacity, thus to fill up the supply shortage in the long run.

Based on this assumption, the current price for raw oil is assumed to be NOK 562 per barrel in 2018. From 2018 onwards, although the real price will keep constant, the nominal price is assumed to increase at a rate of 2% per year onwards. Since raw oil is conventionally priced in the international market in US dollars, the expected annual price change for raw oil is assumed to be the same as that for consumer price index (CPI) in United States, i.e. 2% per year, which is the target of financial policy set by the US Federal Reserve.

Following the national budget, the current price for natural gas per Sm^3 o.e. (standard cubic metres, oil equivalent) is assumed to be NOK 2.15, NOK 2.25, and NOK 2.08 in 2016, 2017 and 2018, respectively. [20] From 2018 onwards, again, it is assumed that the nominal price for natural gas will increase with the same growth rate as that for raw oil, i.e. 2% per year. Similarly, the corresponding real price is assumed to be fixed.

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18 According to the Norwegian Petroleum Directorate (NPD), 1 Sm3 = 6.29 barrel for Norwegian raw oil.

19 Perspektivmeldingen 2013 in Norwegian.

20 See Page 30 in *National budget 2016* (Norwegian Ministry of Finance, 2015) for detailed information. Note that the prices of natural gases as shown in the national budget may include the cost related to pipeline transportation, which is a separate industry. However, due to data limitation, it is ignored for the moment.

As for the price for Norwegian LNG, it is assumed in this paper that its expected price profiles are the same as those for raw oil, for the sake of simplicity.[21]
Note that the expected price profiles for raw oil, natural gas and the LNG in this paper are exogenously given. Because there exists an international market for oil export, even that Norway is the 15th largest oil producer in the world (measured by data for 2014), [22] it is sensible to regard it as a price-taker in the international oil market.

As the 8th largest gas producer in the world (measured by data for 2014),[23] nearly all Norwegian gas is sold on the European continental market through a well-developed and efficient gas infrastructure.[24] The price of natural gas is based on the long-term contract, and is to a large extent connected to the prices of oil and oil-related products in the world. Thus the simple exogeneity assumption also makes sense for Norwegian natural gas.

Compared with raw oil and natural gas, the production of Norwegian LNG is not very significant (see Figure 3.3). Furthermore, the LNG price formation is to an increasingly large extent to be determined internationally rather than regionally as before (such as for natural gas transported by pipelines), given that the LNG can be shipped to, at lease in principle, wherever in the world.

With the expected production and price profiles at hand, the value of the future production output for the Norwegian oil and gas extracting industry as a whole can be easily obtained, first, by the multiplication of the corresponding expected price with production of raw oil, natural gas and the LNG respectively, and then, by the summarisation of the calculated results across raw oil, natural gas and the LNG.
In order to derive the resource rent by using the steps as listed in Table 3.1, however, the corresponding cost information for future production for the industry extracting oil and gas is also needed. The cost for producing oil and gas (including the LNG) consists of intermediate consumption, compensation of employees, consumption of fixed capital, and normal return to produced capital used in the oil and gas extracting industry.

Currently, it is, if not impossible, extremely hard to obtain such detailed information about the expected cost including its various components for future production. There are a number of reasons. For example, the confidentiality is a critical issue, especially at the oil and gas field level. While only at this disaggregated level, can the detailed information on the cost includes its various components and their respective development trends be predicted with better confidence.

Generally speaking, there are many factors that will play important roles in shaping the expected cost profiles for future production. For instance, at the oil and gas field level, on the one hand, the marginal cost of extracting oil and gas is, *ceteris paribus*, to increase when approaching the exhaustion of oil and gas reserve. On the other hand, the absorption of new technologies, more efficient use of capitals including human capital, will decrease the marginal cost given other things unchanged.

[21] In Greaker *et al.* (2005) and the recent updates for accounting national wealth at Statistics Norway, the expected price for Norwegian liquefied natural gas (LNG) was assumed to be 1.05 times of that for raw oil.

[22] See http://www.eia.gov/beta/international/.

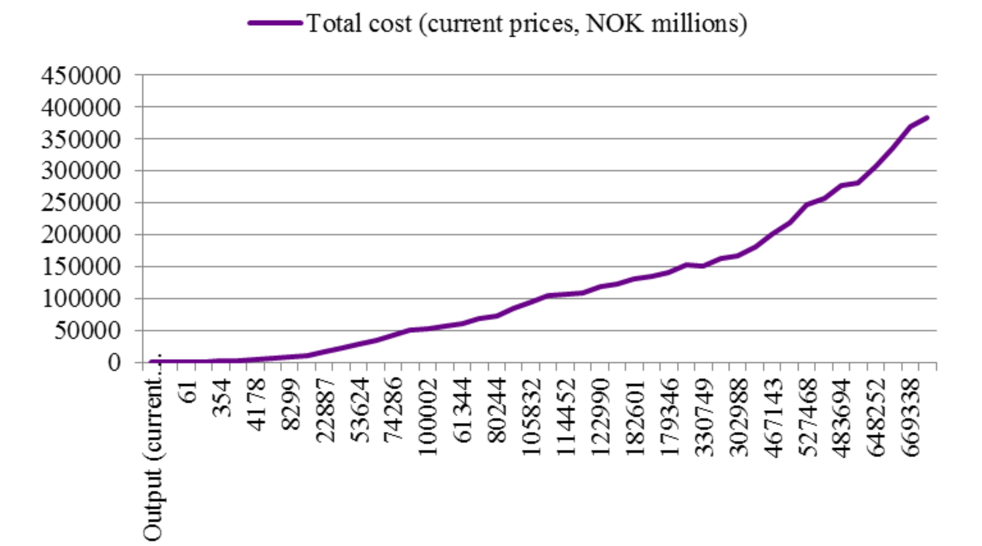
[23] See https://www.cia.gov/library/publications/the-world-factbook/rankorder/2249rank.html.

[24] A fraction of Norwegian natural gas is exported to a spot market in the Great Britain.

At the macro level, while the introduction of either new or higher energy and environment-related taxes (e.g. carbon taxes) internationally will increase the marginal cost of extracting oil and gas in the long run, because both oil and gas are notoriously non-renewable fossil fuels; on the other hand, the new discovery of oil and gas reserves, technological development and dissimilation across countries, will facilitate the reduction of marginal cost of extracting natural resources in the future.

In recognition of the enormous difficulty associated with the prediction of the expected cost profiles, a simple estimation is made in this paper, based on historical information, with the assumption that the pattern/trend as reflected in the history may still hold into the future. Although history may not always repeat itself, it is not unreasonable to make prediction about the future by using the historic as well as the current information.[25]

Figure3. 4. The relationship between output and total cost (1970-2015)



Source: StatBank Norway

By visual inspection on the historical relationship as displayed in Figure 3.4 between the output (in basic values) and the total cost (in current prices) (including intermediate consumption, compensation of employees, consumption of fixed capital, net other taxes/subsidies to production, and normal return to produced assets), an implication can be drawn that there may exist a power function between the output and the total cost.[26]

Consider a power function as follows:

(5) $$y_t = ax_t^b + \sigma_t \text{ ,}$$

Where

y_t = the total cost at time t;

x_t = the output at time t;

[25] The expected share of each cost element (intermediate consumption, compensation of employees, consumption of fixed capital, and normal return to produced capital) in the total cost is assumed to be constant in the future in Greaker *et al*. (2005).

[26] Note that when both the output and the total cost are known, the resource rent can be easily calculated as the difference between the two.

a, b = parameters to be estimated;

σ_t = a random error term, assumed to be lognormal distributed.

Taking natural logarithm on both sides of equation (5) gives the estimation equation applied in this paper with the form as

(6) $\ln(y_t) = c + b\ln(x_t) + \varepsilon_t$,

where

c = $\ln(a)$, a constant;

$\varepsilon_t =$ $\ln \sigma_t$, assumed to have normal distribution with white noise.

With the above assumptions, simple regression by using equation (6) based on historical data (1970-2015) yields the estimated results as shown in Table 3.2. In particular, the estimated parameters $\hat{c}$ = 1.774 and $\hat{b}$ = 0.807, with both being statistically significant.

Accordingly, since the resource rent is simply the difference between the output and the total cost, the expected resource rent is then estimated as follows:

(7) $$NR_t = x_t - \hat{y_t} = x_t - \hat{a}x_t^{\hat{b}} ,$$

where

$\hat{a}$ = $e^{\hat{c}}$;

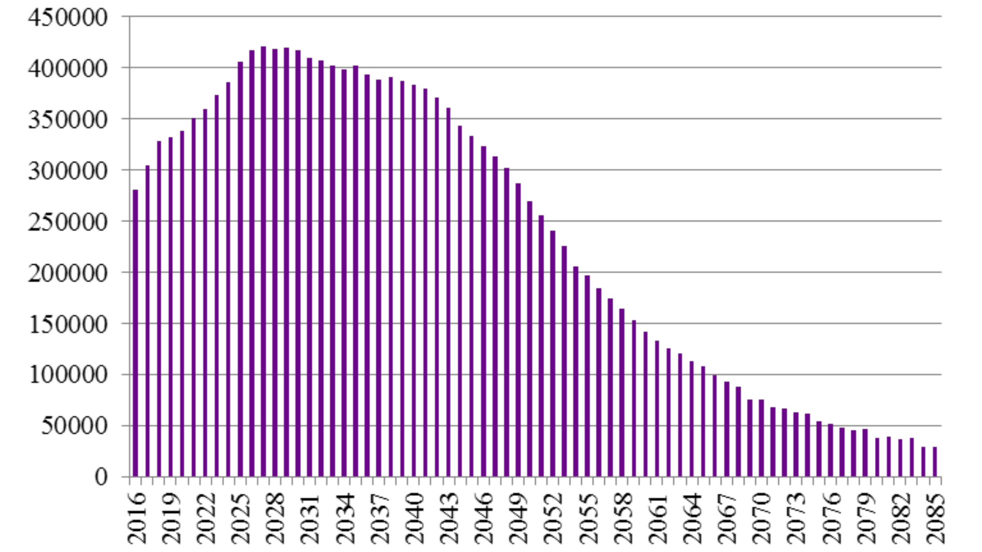
t = 2016, 2017, 2018… 2085.

Table 3.2. Estimation results for total cost function

Ln (cost)	Coefficient estimate	Standard error	t-statistic	P > l t l
Constant	1.774	0.257	6.90	0.000
Ln (output)	0.807	0.022	36.00	0.000
Number of obs.	45			
F(1, 43)	1295.77			
Prob. > F	0.000			
R-squared	0.968			
Adj. R-squared	0.967			
Root MSE	0.329			

The estimated expected nominal resource rents for period 2016-2085 are displayed in Figure 3.5.

Figure 3.5 Expected resource rent from oil and gas (current prices, NOK millions)



Source: Author's calculation based on data from StatBank Norway

3.4. Real resource rent and Norwegian oil and gas wealth (constant 2015 prices)

With the nominal resource rent being estimated for 1970-2085, the next task is to calculate the real resource rent by applying equation (2). To this end, an expected general rate of inflation has to be defined.

Recall that equation (2) can also be written as

(8) $$NR_{t+\tau} = RR_{t+\tau}(1+\rho_t)^{\tau} = RR_{t+\tau} * P_{t+\tau} ,$$

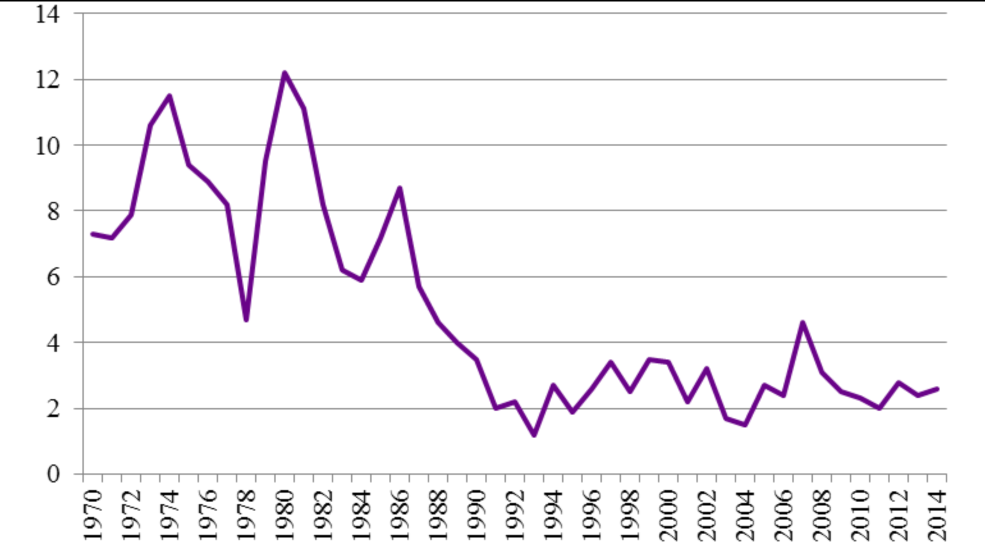
where the price index $P_{t+\tau}$ is defined as the following:

(9) $$P_{t+\tau} = (1+\rho_t)^{\tau}, \tau = 0, 1, 2 \ldots T_t .$$

Thus, a price index is compiled based on annual price changes for general consumption that includes not only private final consumption but also the final consumption by general government (including central and local governments). The reason is that ultimately, the resource rent is expected to meet the needs for final consumption.

Figure 3.6 displays the annual price changes for general consumption that are directly drawn from the StatBank Norway for the period 1970-2015. From 2016, annual price changes are assumed to keep constant at 2% until 2085. Based on these assumptions and by applying equation (9), the price index needed is derived with the price for 2015 being set equal to 1.

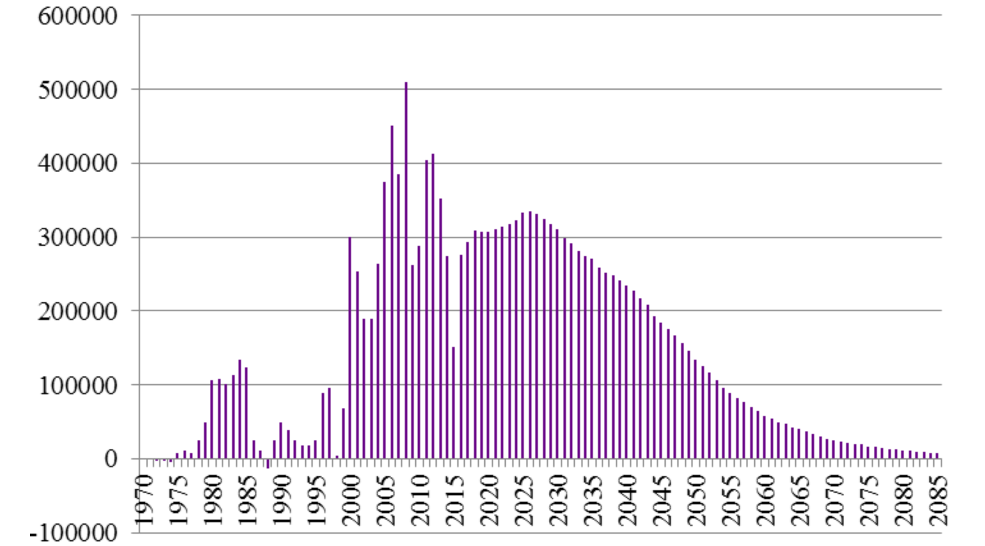
Figure3. 6. Annual price changes for general consumption, 1970-2015 (%)



Source: StatBank Norway

Applying the derived price index to the nominal resource rents for the period 1970-2085, the real resource rents in constant 2015 prices are calculated by means of equation (8), and are displayed in Figure 3.7.

Figure 3.7. Real resource rent from oil and gas (constant 2015 prices, NOK millions)



Source: Author's calculation based on data from StatBank Norway

Finally, following the NPV approach with the application of equation (3), and using 4% as the expected annual real discount rate, the Norwegian oil and gas wealth for 1970-2015 is calculated and displayed in Figure 3.8 for the wealth in total, and in Figure 3.9 for the wealth per capita, all in constant 2015 prices (also see Table A2 in Appendix for detailed figures).

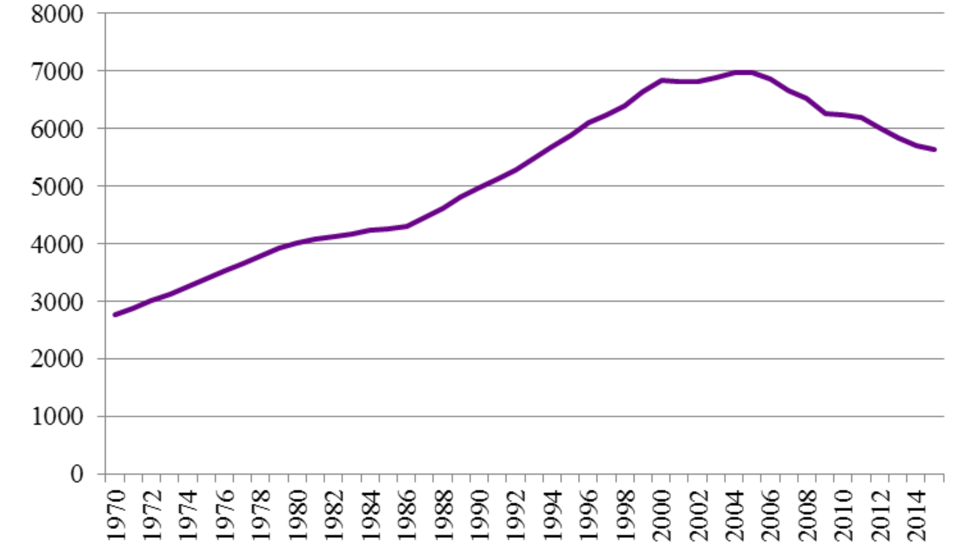
Note that when applying equation (3) in our calculation of the oil and gas wealth, additional implicit assumptions have been made for the two exogenous parameters. First, the remaining asset life T_t , an estimated number of remaining periods of extraction at time t, is assumed to decline by one period as time t progresses, given that a fixed finite period of exploitation is assumed, i.e. the total oil and gas resource is approaching zero in 2085, based on experts' assessment by the NPD.[27]

[27] Note that if the exploitation of a natural resource is judged to be sustainable, such as for renewable natural resources, the remaining asset life T_t will take an infinite value and is independent on time t.

Second, the expected annual real discount rate r_t is assumed to be 4%, a constant for the whole period 1970-2085 covered by this paper, although it could be time dependent in principle as shown in equation (3). The 4% expected annual real discount rate was also applied in Greaker *et al*. (2005) and in Norwegian Ministry of Finance (2000) for national wealth accounting. In addition, this assumption is consistent with that the annual expected long-term real rate of return to the GPFG fund is set as 4% by the Norwegian Ministry of Finance (2012).

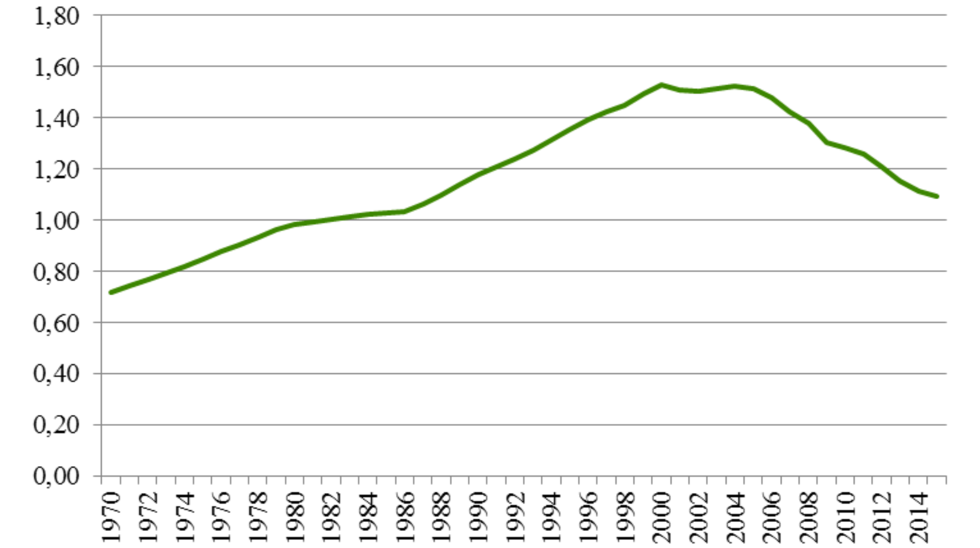
As shown in Figure 3.8 and 3.9 (as well as in Table A2 in Appendix), the estimated Norwegian oil and gas wealth increases monotonously ever since 1970s, and all the way up into the beginning of the 21th century. After reaching its peak, at 2005 for the total wealth, and at 2000 for the wealth per capita, it is now decreasing already.

Figure 3.8. Norwegian oil and gas wealth, 1970-2015 (constant 2015 prices, NOK billions)



Source: Author's calculation based on data from StatBank Norway

Figure 3.9. Norwegian oil and gas wealth per capita, 1970-2015 (constant 2015 prices, NOK millions)

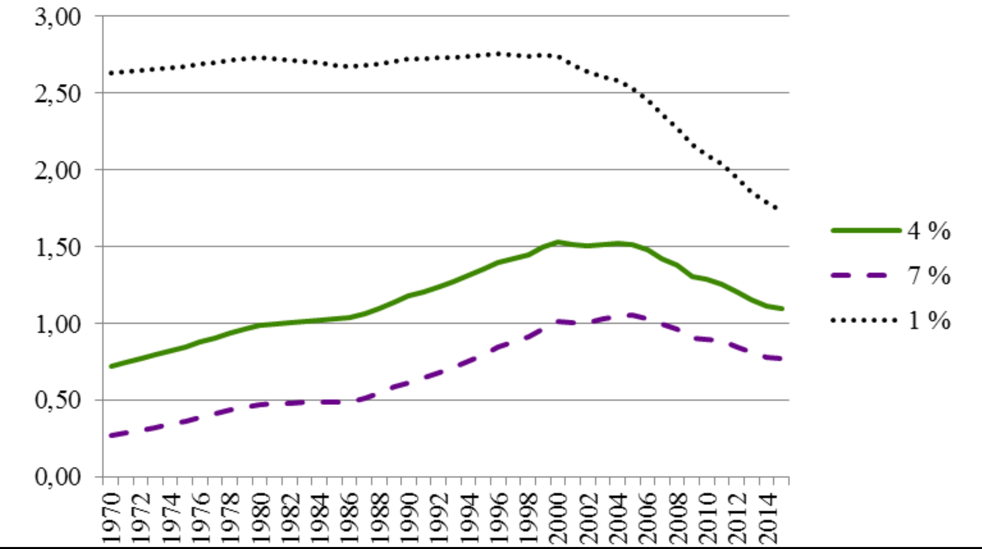


Source: Author's calculation based on data from StatBank Norway

Formally, a sensitivity analysis is also implemented with respect to the key parameter applied in this paper, i.e. the expected annual real discount rate. As demonstrated in Figure 3.10, the estimated Norwegian oil and gas wealth per capita in constant 2015 prices for the period 1970-2015 by using different discount rates

(4%, 7% and 1%),[28] albeit varied in levels, shows a similar trend, i.e. it has been decreasing after the peak was passed around 2000.

Figure 3.10. Norwegian oil and gas wealth per capita, 1970-2015 (constant 2015 prices, NOK millions), sensitivity analysis w.r.t. expected annual real discount rate



Source: Author's calculation based on data from StatBank Norway

A shrinking oil and gas wealth in per capita terms is not a good sign of sustainability if only oil and gas wealth is considered here, since one of the important income sources in Norway is dwindling in the days to come. However, if the resource rent from depletion of this non-renewable resources (raw oil and natural gas) is entirely invested in produced capital, sustainability is still achievable, according to the so-called Hartwick's rule (Hartwick, 1977).

In accordance with this theory and by learning from the lessons drawn from e.g. 'Dutch disease'[29], the Norwegian government decided to set up the GPFG, with the purpose to maintain the oil and gas wealth that is generated from extracting oil and gas and to invest the accumulated oil and gas money into the global capital market, which is a necessary condition for reaching sustainability for a resource-rich country like Norway.

4. Concluding remarks

Based primarily on Norwegian national accounts statistics, and supplemented with experts' prediction about the expected profiles of production and price for raw oil, natural gas and the LNG, this paper makes estimation of the Norwegian oil and gas wealth for the period 1970-2015, by means of the NPV approach, as recommended by the latest SEEA.

The estimated results demonstrate that in per capita terms, the Norwegian oil and gas wealth in constant (2015) prices has already passed its peak around 2000 and now is decreasing, which signals unsustainability if merely oil and gas are concerned. However, since a large part of the resource rents from extracting oil and

[28] The 7% was once applied as the expected annual real discount rate in Brekke *et al.* (1989).

[29] The term 'Dutch disease' originates from a crisis in the Netherlands in the 1960s that resulted from discoveries of vast natural gas deposits in the North Sea. The newfound wealth caused the Dutch guilder to rise, making exports of all non-oil products less competitive on the world market.

gas are invested into other types of assets through the GPFG, it may not be so worrisome in terms of sustainability.[30]

In this paper, most of the exogenous parameters are chosen with an intention to maintain as much as possible the comparability with other research reports, e.g. the internal reports (e.g. Greaker, et. al., 2005) at Statistics Norway and the national budget by Norwegian Ministry of Finance. At the same time, the consistency of the concept, definition and methodology between the SNA and the SEEA is also maintained in purpose.

Sensitivity analysis with respect to the expected annual real discount rate shows that while the absolute level of Norwegian oil and gas wealth per capita is sensitive to the choice of this key parameter, the trend over time, however, is not.

Other key exogenous parameters as applied in this paper include the expected production and price profiles for Norwegian oil, gas and the LNG. The wide application of these predicted profiles by both Statistics Norway and Norwegian Ministry of Finance, however, does not necessarily mean that consensus has been reached; rather, the choice of these profiles needs more theoretical and practical backups.

Taking this into consideration and given that the final estimates of the Norwegian oil and gas wealth is certainly dependent on the choice of these predicted profiles, sensitivity analysis, though not done in this paper, should be investigated in the future.

At present, the resource rent is calculated for oil and gas collectively, while a better measurement of the resource rent should be undertaken for oil and gas separately, in recognition of that both the use and price formation for oil or gas are rather different in reality.[31]

Although individual production data for either oil or gas is available in the Norwegian national accounts datasets, the associated individual costs for either oil or gas (including intermediate consumption, labour and capital inputs, etc.), however, cannot be easily obtained from the cost information solely for the oil and gas industry as a whole. The allocation of the industry cost in its entirety to either oil or gas extraction specifically needs further detailed information beyond the current Norwegian national accounts datasets.

Indeed, an even better measurement of the resource rent could be implemented by exploiting information at more disaggregated level, such as information at oil and gas field level. Knowing the existence of high heterogeneity across oil and gas fields, this bottom-up approach could be an interesting topic for future research.

Currently, this paper only calculated the oil and gas wealth that is to be employed as an item in the balance sheets of the Norwegian national accounts. In order to decompose the changes of the oil and gas wealth into extraction, revaluation and other changes between the consecutive balance sheets accounts, data from the natural resource physical accounts are needed. How to systematically link the flows to the changes of the stock within the SEEA framework serves as another important topic for future research as well.

[30] A necessary condition for a country to achieve sustainability is that in per capita terms, the country's total wealth, consisting of produced, natural, and human capital, is not decreasing over time (UNECE, 2009).

[31] For example, the use of oil is dominant in transportation sector, while gas is largely used for stationary burning. Though both fossil fuels, gas is considered relatively 'cleaner' than oil, and will be levied lower environmental tax accordingly.

References

Aslaksen, I., K. A. Brekke, T. A. Johnsen and A. Aaheim (1990), 'Petroleum Resources and the Management of National Wealth', in O. Bjerkholt, Ø. Olsen and J. Vislie (eds.), *Recent Modelling Approaches in Applied Energy Economics*, Chapman and Hall Ltd.

Brekke, K. A., T. A. Johnsen and A. Aaheim (1989), 'Petroleumsformuen - prinsipper og beregninger', *Økonomiske analyser* 1989/5, Statistics Norway

Brunvoll, F., S. Homstvedt and K. E. Kolshus (2012), Indikatorer for bærekraftig utvikling 2012, *Statistical Analyses*, No. 129, Statistics Norway

Cappelen, Å., T. Eika and J. B. Prestmo (2013), 'Petroleumsvirksomhetens virkning på norsk økonomi og lønnsdannelse - Framtidig nedbygging og følsomhet for oljeprissjokk', Report 2013/59, Statistics Norway

Eurostat (2013), *European System of Accounts 2010*

Eurostat (2014), *European System of Accounts 2010, Transmission Programme of Data*

Fjærli E. and D. Lund (2001), 'The Choice Between Owner's Wages and Dividends under the Dual Income Tax', *Finnish Economic Papers,* 14 (2), 104 - 119.

Greaker, M., P. Løkkevik and M. A. Walle (2005), 'Utviklingen i den norske nasjonalformuen fra 1985 til 2004 - Et eksempel på bærekraftig utvikling?' Report 2005/13, Statistics Norway

Hartwick, J. M. (1977), 'Intergenerational Equity and the Investing of Rents from Exhaustible Resources', *American Economic Review* 67 (5), 972-974.

Lindholt, L. (2000), 'On natural resource rent and the wealth of a nation', *Discussion Paper* No.281, Statistics Norway.

Liu, G. (2013), 'Wealth accounting in Norway', paper presented at OECD Working Party on National Accounts Conference, Paris, STD/CSTAT/WPNA(2013)18

Liu, G. (2014), "Measuring the Stock of Human Capital for International and Inter-temporal Comparisons", in D. Jorgenson, S. Landefeld and P. Schreyer (ed.), *Measuring Economic Sustainability and Progress*, National Bureau of Economic Research volume, The University of Chicago Press.

Norwegian Ministry of Finance (2000), 'Melding til Stortinget, nr. 29 (2000-2001), Retningslinjer for den økonomiske politikken'

Norwegian Ministry of Finance (2012), 'Melding til Stortinget, nr. 12 (2012-2013), Perspektivmeldingen 2013'

Norwegian Ministry of Finance (2015), 'Melding til Stortinget, nr. 1 (2015-2016), Nasjonalbudsjettet 2016'

UNECE (2009), *Measuring Sustainable Development*, Report of the Joint UNECE/OECD/Eurostat Working Group on Statistics for Sustainable Development , New York and Geneva.

United Nations (2009), *System of National Account 2008*

United Nations (2013), *System of Environmental-Economic Accounting 2012 – Central Framework*

Appendix A: Tables

Table A1. Expected production profiles for oil, gas and LNG (millions, Sm^{3}o.e.)

Year	Raw oil	Natural gas	LNG
2015	88	108	22
2016	86	106	22
2017	85	109	22
2018	82	112	22
2019	81	113	21
2020	81	112	21
2021	87	108	19
2022	91	104	18
2023	95	102	17
2024	100	100	15
2025	107	97	14
2026	109	96	13
2027	108	96	12
2028	107	94	10
2029	104	94	10
2030	100	94	10
2031	95	94	9
2032	91	94	9
2033	87	93	9
2034	84	93	8
2035	82	93	8
2036	77	92	8
2037	73	92	8
2038	71	92	8
2039	69	91	7
2040	66	90	7
2041	64	87	7
2042	62	84	6
2043	59	81	6
2044	56	76	5
2045	53	73	5
2046	52	67	5
2047	50	63	5
2048	47	60	5
2049	44	56	5
2050	41	53	4
2051	38	50	4
2052	35	47	4
2053	32	44	4
2054	29	41	3
2055	27	39	3
2056	25	36	3
2057	23	34	3
2058	21	32	3
2059	19	30	3
2060	18	28	2
2061	16	27	2
2062	15	25	2
2063	14	24	2
2064	13	22	2
2065	12	21	2
2066	11	19	2
2067	10	18	2
2068	9	17	2
2069	8	16	1
2070	8	15	1
2071	7	14	1
2072	7	13	1
2073	6	13	1
2074	6	12	1
2075	5	11	1
2076	5	10	1
2077	4	10	1
2078	4	9	1
2079	4	9	1
2080	3	8	1
2081	3	8	1
2082	3	7	1
2083	3	7	1
2084	2	6	1
2085	2	6	1

Source: Norwegian Ministry of Finance (2015)

Table A2. The wealth of Norwegian oil and gas, 1970-2015 (constant 2015 prices)

Year	Oil and gas wealth (NOK billions)	Oil and gas wealth per capita (NOK millions)
1970	2779	0.72
1971	2891	0.74
1972	3009	0.77
1973	3131	0.79
1974	3260	0.82
1975	3396	0.85
1976	3524	0.88
1977	3653	0.91
1978	3791	0.94
1979	3916	0.96
1980	4021	0.99
1981	4071	0.99
1982	4122	1.00
1983	4182	1.01
1984	4231	1.02
1985	4261	1.03
1986	4302	1.03
1987	4449	1.07
1988	4615	1.10
1989	4813	1.14
1990	4979	1.18
1991	5128	1.21
1992	5293	1.24
1993	5479	1.27
1994	5680	1.31
1995	5888	1.35
1996	6098	1.40
1997	6250	1.42
1998	6399	1.45
1999	6652	1.50
2000	6847	1.53
2001	6808	1.51
2002	6816	1.51
2003	6890	1.51
2004	6970	1.52
2005	6973	1.51
2006	6863	1.48
2007	6669	1.42
2008	6535	1.38
2009	6266	1.31
2010	6244	1.29
2011	6194	1.26
2012	6021	1.21
2013	5833	1.15
2014	5701	1.12
2015	5645	1.09

Source: Author’s calculation based on data from StatBank Norway

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The wealth of Norwegian raw oil and natural gas: 1970-2015

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