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Calculations applying the National Accounts

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Abstract:
Extraordinarily high returns in a sector based on the extraction of a natural resource can be referred to as resource rents. This study uses the National Accounts and the definitions of the System of Environmental-Economic Accounting to calculate the resource rents in Norwegian aquaculture in the period 1984-2020. If we know the remuneration of all input factors such as capital, labour and technology except the remuneration of the aquacultural services, the resource rent will appear as the difference between the value of output and the remuneration of all other input factors. We argue that we are to a large extent able to separate other input factors from aquacultural services. We perform various sensitivity analysis as introducing higher rates of return, applying alternative wage costs and by treating the stock of fish as real capital. A robust conclusion is that there has been a significant resource rent in aquaculture since 2000 and that it has risen markedly since 2012. In the period 2016-2020 it has averaged 18-20 billion NOK.

Keywords: Resource rent; aquaculture; National Accounts; System of Environmental-Economic Accounting

JEL classification: Q22; L11; E22

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Sammendrag

Inntekter fra naturressurser er knyttet til begrepet ressursrente eller grunnrente. Ressursrenten er den inntekten fra å utnytte en naturressurs som blir igjen etter at alle nødvendige innsatsfaktorer har fått sin markedsmessige avlønning. Grunnrenten er altså merinntekten av å disponere en naturressurs, eller med andre ord; det man tjener utover det man normalt ville ha tjent ved å investere realkapital og humankapital i andre virksomheter. Det er bare et begrenset antall steder (lokaliteter) i Norge og hele verden som er egnet for havbruk, og dette gir opphav til ressursrente. Gode lokaliteter avhenger blant annet av klimatiske forhold, kvalitet på sjøvann og beskyttelse mot vær og vind. I likhet med andre naturressursnæringer kan begrenset adgang også betraktes som et resultat av samspillet mellom ressursknapphet og regulering av næringen i form av et begrenset antall produksjonstillatelser.

Utgangspunktet for beregning av ressursrenten er at produksjon av en naturressurs kan uttrykkes ved en produktfunksjon, der en eller flere økosystemtjenester inngår som innsatsfaktorer. Hvis vi kjenner godtgjørelsen til alle innsatsfaktorer som kapital, arbeidskraft og teknologi unntatt godtgjørelsen til tjenestene fra de marine økosystemtjenester, vil ressursrenten fremstå som forskjellen mellom verdien av produksjonen og godtgjørelsen til alle andre innsatsfaktorer. Vi argumenterer for at vi i stor grad klarer å skille mellom bidraget til produksjon fra marine økosystemtjenester og andre innsatsfaktorer. Vi argumenterer også for at verdien av fiskeoppdrettstillatelser ikke bør regnes som kapital, fordi det i våre beregninger er lisensene som gir opphav til ressursrente.

Ved å bruke tall og definisjoner i Nasjonalregnskapet og definisjonen i System of Environmental-Economic Accounting (SEEA) beregner vi ressursrenten i havbruk i Norge fra 1984 til 2020. Fra 2000 til 2020 er ressursrenten i gjennomsnitt nesten 8 milliarder NOK (2020-NOK), til tross for svake resultater i årene 2001-2004. Etter 2012 har ressursrenten steget markant. I de siste 10 årene har ressursrenten i gjennomsnitt vært nesten 14 milliarder. I de siste fem årene har den vært over 20 milliarder kroner, til tross for et relativt svakt år (12 milliarder) i 2020 som følge av koronapandemien.

Vi utfører ulike sensitivitetsanalyser som betydningen av høyere avkastningskrav, alternative lønnskostnader og konsekvensene av regnskapsmessig å behandle fiske i merdene som realkapital. Disse endrer ikke konklusjonen om at det har vært en betydelig ressursrente i norsk havbruk siden 2000, og at den har økt markant siden 2012.

1. Introduction

Revenue from natural resources is related to the term resource rent (RR). The RR is the income from utilizing a natural resource that remains after all necessary input factors have received their remuneration (see e.g. SEEA, 2014). RR is thus the additional income of using a natural resource, or in other words; what you earn beyond the income you would normally have earned by investing in real capital and human capital in other industries.

The starting point for calculating the RR is that production can be expressed by a production function, where one or more ecosystem services are included as input factors (Ministry of Climate and Environment, 2013). It is the remuneration of these ecosystem services that we are looking to identify, and which we call the RR. In this study we look at the aquacultural services provided by the marine ecosystems in the production of salmon and trout. The marine ecosystem services are linked to environmental conditions (e.g. salinity, tides, currents, seawater temperature, oxygen levels, carrying capacity of the seabed and surrounding seawater). The production function in aquaculture also includes other input factors such as labour, capital and technology. If we know the remuneration of all input factors except the remuneration of the aquacultural services, the RR will appear as the difference between the value of output and the remuneration of all other input factors. We argue that we to a large extent are able to separate other input factors from aquacultural services.

There are several reasons why natural resources can give positive RR. The starting point for all the explanations is that natural resources are scarce and/or with limited access (see e.g. Brekke and Lurås in Brekke et al. 1997). This means that one can achieve positive profits on utilizing a natural resource over a long period of time, without entry of new suppliers. Or, to put it another way, the limited access prevents free entry that would otherwise have pushed the profits down to the normal return on capital. In addition, sites with more favourable environmental conditions cam give rise to a higher resource rent compared to lower quality sites. However, not all natural resources will lead to positive RR. In some cases it may simply be too costly to extract the resource compared to the market's willingness to pay. In other cases, the way the extraction is organized can entail too high costs and an inappropriate level of extraction so that RR becomes zero. The so-called tragedy of the commons is an example of the latter (Hardin, 1968).

There are only a limited number of locations worldwide and in Norway which is suitable for aquaculture activities and this give rise to RR. Good localities depend, among other things, on climatic conditions, qualities of seawater and protection from weather and wind. As with other natural resources, limited access in aquaculture can also be considered as the result of the interaction between resource scarcity and regulations in the form av a limited number of licenses.

Statistics Norway has calculated the value of Norwegian natural resources for several years based on data from the National Accounts (NA) (see e.g. Greaker et al., 2005; 2016; 2017). The resources included in the Norwegian NA are the renewable natural resource sectors; agriculture, forestry, aquaculture, fisheries and power production (and occasionally also agriculture and fishing for own use and hunting, and the nonrenewable natural resources; oil, gas and minerals. See Aslaksen and Glomsrød (2021) for an updated time series estimation of RR in oil and gas, forestry, fisheries and hydropower.

In this paper we will study the development of the realized RR in Norwegian aquaculture from 1984 to 2020. Thus, the calculations are based on the existing management regime prevailing each year. The starting point for our estimations is a Norwegian report (Greaker and Lindholt, 2019), which was used by Ministry of Finance (2019). However, we extend the time series and first and foremost we also add further calculations and discussions based on critique of the methods used in the report (see e.g. Arnason and Bjørndal, 2020). Even if we build on the traditions of RR estimations in Statistics Norway, our time series is now fully consistent with the System of Environmental-Economic Accounting 's (SEEA) definition of the components of RR (SEEA, 2014). Arnason and Bjørndal (2020) claim that in the Norwegian report we simply assume that profits are resource rents, and that we fail to include the opportunity costs of farming permits as well as various intangible inputs. Misund et al. (2019) argue that we should deduct the value of permits from the RR and include the stock of fish in the sea as capital. Furthermore, they argue that we should apply higher discount rates which is appropriate for projects with e.g. a high systematic risk. Due to this criticism we include a discussion of whether we manage to isolate the RR from regulatory rent, market rent and intra-marginal rent due to company-specific knowledge and technology. Such a discussion is a novelty compared to similar studies of RR, e.g. the study of Norwegian fisheries in Greaker et al. (2016, 2017). Another novelty is the discussion of the connection between risk and the appropriate rate of return to use. Furthermore, we have not seen other studies of aquaculture that derive the effects of treating the stock of fish as real capital. Lastly, we look at the correct way to treat the value of permits in the measurement of RR.

Flåten and Pham (2019) estimate the RR in the companies which is included in the Directorate of Fisheries' profitability survey (Directorate of Fisheries, 2021) to about 19 billion NOK (2019-NOK) in 2016. If this estimate is scaled up to include all aquaculture companies, the RR can be estimated to approximately 27 billion. Ministry of Finance (2019) applies tax data and show that the RR has varied from about 10 to about 23 billion NOK (2019-NOK) in the period 2013 to 2017. By using the NA over the period 1984-2020, we find in our study that there has been a significant RR in aquaculture since the year 2000 as the average yearly RR in this period is almost 8 billion NOK (2020-NOK). The RR in aquaculture has increased significantly from 2012, and in the period 2016 to 2020 it has averaged over 20 billion NOK annually. The conclusion that there has been a significant RR since 2000, also holds when we run various sensitivity analysis.

2. A valid measure of resource rent

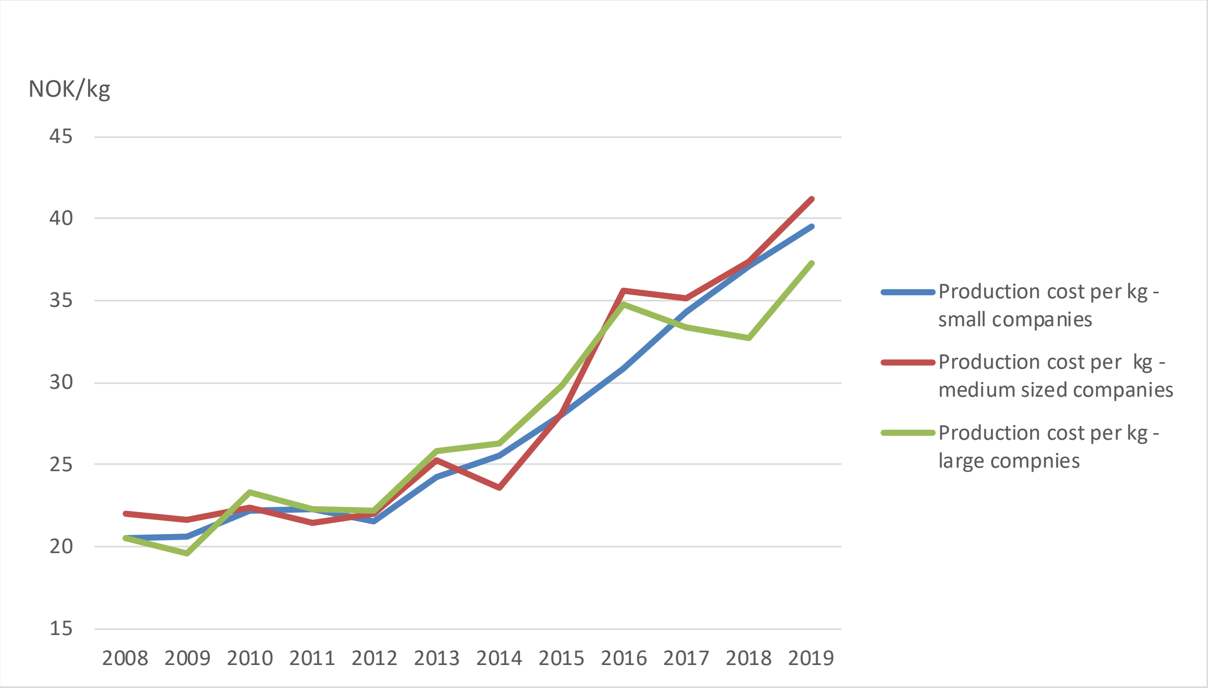
Regulation of a natural resource sector prevents entry that would otherwise have pushed the profits down over time to the normal return on capital. Hence, a lasting RR can only be realized through resources management and for this reason it is sometimes called regulatory rent (or management rent) (Anderson, 1989). In this study, the term resource rent and regulatory rent are assumed synonymous, because for our objective it is not important if limited access is the result of regulation or natural scarcity.

As we have pointed out there can be RR in aquaculture due to scarcity and/or regulations. Furthermore, differences in site-specific nature characteristics may cause profitability differences among farms, and this can also be classified as RR (Flåten and Pham, 2019). Asche et al. (2020) explain how some sites are known to be more productive due to favourable environmental conditions. Thus, the profit in an industry as aquaculture can be divided into a RR due to scarcity/limited access and favourable natural conditions. In addition, when the aquaculture industry faces a downward sloping demand for its products, limited access may limit the output of fish, thereby increasing the price compared with that of perfect competition. This is the case whether the official arguments for limited access are for environmental protection or market reasons (Flåten and Pham, 2019). Thus, some parts of the RR may be regarded as market rent. However, the income can also be due to company-specific knowledge and technology. This is called the intra-marginal rent. According to Arnason and Bjørndal (2020) the RR in aquaculture does not necessarily arise from the natural resource services. They argue that various other factors of production are invariably involved in generating these rents including the technology in use and the efficiency of the harvesting activity.

Price differences tend to be limited between aquaculture firms (The Directorate of Fisheries, 2021). Consequently, the differences in profits are likely to result from differences in the cost of production. Costs, again, could be the result of variations in the quality of sites between companies and/or company efficiency. It is the latter component we would want to separate from the RR. However, as we only can observe the combined impact of both these factors on costs, it is difficult to determine the contribution of each one of them.

According to Misund et al. (2019) annual cost studies undertaken by The Directorate of Fisheries show substantial differences between farms when it comes to average cost of production per kg of salmon. Even if they argue for the existence of intra-marginal rent due to e.g. technology, they cannot separate this rent from the RR. Further, Arnarson and Bjorndal, 2020) claim that profits are a poor measure of RR in aquaculture even without performing any empirical analysis. The Directorate of Fisheries (2021) presents variable costs for small (1-9 licenses), medium (10-19 licenses) and large (over 20 licenses) salmon and trout companies for the period 2008-2019. One could assume that larger companies have acquired the most efficient technology and that this should lead to lower costs. However, Figure 1 show that there are no systematic differences in production costs of salmon and trout between aquaculture companies of different size groups. We cannot reject the null-hypothesis that the costs are equal through an unpaired t-test between the three possible pairs of company size groups. Hence, small or no differences in economic profits between size classes could be an *indication* of a high share of RR and a low share of intramarginal rent since no size groups are more

Figure 1. Production costs for different company size groups 2008-2019.



technically efficient than others. However, as is also the case with the above-mentioned studies, separating economic rent from intra-marginal profit is empirically quite challenging.

The capital equipment of salmon farms includes open cages in seawater, a floating barge for production surveillance room and feed storage, anchoring systems, and automated feeding systems. The production technology includes digital sensor technologies for monitoring the environment and live salmon. The role of the farm manager and labor is primarily monitoring of the farm, making feeding decisions, maintenance and assisting release and harvesting of live salmon in and out of the cages (Misund and Tveterås, 2020). In our estimations we include real capital. The value of real capital encompasses the quality of the production equipment described above. Investment in fixed capital also includes own *R&D* activity. *R&D* may represent company-specific knowledge and technology. There are various studies that apply *R&D* as a proxy for technological change, see e.g. Lindholt (2015). Hence, the return on real capital which includes total *R&D* activity in aquaculture represents at least part of the intra-marginal rent. We cannot take into consideration that *R&D* activities in other sectors might affect the technology and return in aquaculture. Furthermore, according to Arnason and Bjørndal (2020) various studies that try to measure RR, miss the role of intangible inputs such as the entrepreneurship, network and management, which may affect the profits of companies. Our estimations also include input costs for labour, which could also encompass the operational skills of aquacultural workers. Employees will normally receive remuneration through wages in line with his/her productivity. In addition, entrepreneurship may be linked to higher *R&D* activity. Hence, from the discussion above we argue that we to a large extent are able to separate between the contribution to the value of output from the remuneration of aquacultural services and other input factors.

We do not agree that the value of permits should be deducted from the RR as claimed by e.g. Misund et al. (2019). Theoretically, the value of the RR value can be considered as the highest permit price a producer would be willing to pay to get access to the aquacultural resource. As the value of permits represents the origin of the RR itself, it should not be included in the calculation of RR. RR is precisely the accrued value of the permits and in a well-functioning market, the turnover value of such permits reflects the present value of owning and using the permits in the future. This thus reflects not just future RR based on the current management regime, but also expectations of any changes in regulations and the aquaculture otherwise (Ministry of Finance, 2019). The revenue from a well-designed auction of licenses without time limit would in principle be the total present value of the expected future RR.

3. Method for calculation of resource rent using National Accounts

3.1. Introduction

In the NA «aquaculture» includes «stock changes, fish farming», «salmon and trout farming», «cod farming», «other fish farming», «fish fry, young fish and aquarium fish», «investment work fishing and machinery» and «income from freight traffic». It would have been desirable to separate "salmon and trout farming", "cod farming" and "other fish farming". However, it is not possible to obtain separate numbers from NA for work effort, capital stock, etc. for these groups. However, the RR for total aquaculture as a whole should be a highly valid estimate for the RR in fish farming, as "salmon and trout farming" over the last 10 years has contributed to between 80 and 90 per cent of the output in "aquaculture".

We will now turn to the calculation of RR. Since we apply figures from the NA, we use the definition according to SEEA (SEEA, 2014). The definition is in principle the same as in Ministry of Finance (2005) and Greaker et al. (2005), but the terminology is somewhat different. The general calculation method of RR in Norwegian natural resource sectors is presented in Table 1.

Table 1. The composition of resource rent according to the System of Environmental Economic Accounting (SEEA).

Output
- Intermediate uses
= Value Added
- Other taxes on production
+ Other subsidies on production
- Compensation of employees (input costs for labour)
= Gross operating surplus (NA basis)
- Specific subsidies on extraction
+ Specific taxes on extraction
= Gross operating surplus (for the derivation of resource rent)
- Consumption of fixed capital (depreciation)
- Return to produced assets
= Resource rent (RR)

3.2. Output and resource rent

The value added earned through domestic production activity in an industry is defined as output minus intermediate uses. Intermediate uses are goods and services consumed or used up as inputs in production. In aquaculture these are e, g. the purchase of fish fry (smolts) as well as feed for the fish in the net pens. When calculating output in aquaculture, both actual sales of fish and changes in inventories are included (i.e. the change in the stock of fish in net pens/containers). To get the gross operating surplus (SNA basis), we deduct other taxes on production and add other subsidies on production and in addition we deduct compensation of employees. Since output includes all subsidies on products and excludes taxes on products, we must adjust for this by adding product taxes (specific taxes on extraction) and deduct product subsidies (specific subsidies on extraction) to get the gross operating surplus (for the derivation of resource rent). Finally, we deduct return on fixed capital and capital consumption from the gross operating surplus to get the RR.

3.3. Taxes and subsidies

Product taxes and subsidies, called specific taxes/subsidies on extraction in Table 1, are taxes/subsidies levied directly on the product. A product tax is paid by the specific resource industry and must therefore be added to the RR, while a product subsidy must be subtracted. This is because taxes on products can be regarded as a part of the value that is created by the industry when the resource is extracted, while a product subsidy can be seen as part of the costs of extracting the resource (e.g. price support). Among the natural resource sectors only agriculture has product subsidies. Basically, there are no industries that have product specific taxes, i.e. taxes which vary proportionally with production.

In addition to the products taxes/subsidies there are taxes/subsidies that are more industry specific, as they follow the industry and not products, i.e. they are imposed independently of the production volume. The SEEA give no guidance to whether these should be included or not. However, we follow Ministry of Finance (2005) and Greaker et al. (2005) who conclude that industry specific taxes/subsidies should not be considered when calculating the RR. These industry specific taxes/subsidies can influence the cost structure in the industry, e.g. investment subsidies may have led to too overcapitalization and disproportionately high labour use. Even though the industry specific subsidies in this manner indirectly may have reduced the RR as we measure it, we do not include them in the calculations. Our calculations only reveal the size of the RR given the institutional framework conditions, and do not say anything about how large or small the RR could potentially have been.

The other production taxes should be deducted and vice versa for the other production subsidies. The reason is that these taxes/subsidies must in any case be paid regardless of industry. They can therefore be considered as normal operating costs/income by doing business. We have not found any examples of these non-industry-specific taxes/subsidies in the NA other than employer's social security and pension contributions and taxes on vehicles. However, we have not deducted this annual tax on motor vehicles as it accounted for less than 0.1 per cent of output in aquaculture production in 2016. We also do not interpret deductions of expenditure on *R&D* (SkatteFUNN) in aquaculture as a non-industry-specific subsidy. The amount is not a general support from running a business and it is not given to everyone. Further, the support amounted to less than 1 per cent of the value added in 2016.

3.4. Wage compensation

Compensation of employees are wages and employer's social security and pension contributions. Both components are subtracted from the value added in the RR calculations. The deduction of employer's social security and pension contributions is consistent with the deduction of other production taxes (as described in Section 3.3). The reason is that these taxes must be paid regardless of industry and can therefore be regarded as normal operating costs in doing business.

Wage compensation must reflect the alternative use value of the labour force. To calculate the wage compensation, we have first calculated an average hourly wage rate. This rate is obtained by taking the wage costs for mainland Norway divided by the number of hours worked for employees in mainland Norway. The reason why we use wages for mainland Norway and not the whole of Norway is that wage rates are particularly high for the oil and gas industry, probably because the high operating results have allowed for local wage increases. To find the wage compensation in the individual industry, the hourly wage rate is multiplied by the total hours worked for wage earners and self-employed. Thus, the wage cost per man hour of aquaculture farmers is assumed to equal the average wage rate in the mainland economy.

One can discuss whether the wage calculations described above give a correct picture of the alternative value of the labour force. The level of education in the aquaculture (and other primary industries) is relatively low, i.e. the average wage rate per year for mainland Norway is probably too high to apply to this industry and this reduces the RR. An alternative calculation method is to use the actual wage costs for aquaculture as they appear in the NA. This is done in the sensitivity analyses in Section 4.2.2.

3.5. Capital costs

In the same way as wages reflect the alternative value of labour, the cost of capital should reflect the alternative value of capital. The capital cost consists of two components; capital consumption and the return on existing real capital stock. From NA we can collect the value of capital in aquaculture. The capital concept includes i.e. machinery and equipment, buildings and means of transport. NA have for aquaculture registered "ships and vessels", "vans", "commercial buildings", "machinery" and "other facilities". All these objects make up the value of real capital. In addition, the capital concept includes *R&D* and other intangible capital (goodwill is not included in NA) registered as "own *R&D*".

The value of the fish in the sea is not included in the capital stock in NA. The reason is that fish in net pens are not defined as "livestock" in NA in line with cows and sheep. The stock of cows and sheep yields a return in the form of e.g. milk, offspring and wool without being slaughtered. Thus, fish in the sea shall not be included in the capital stock. Purchases of smolt and feed are intermediate input factors in the production that is "built into" the product being sold. Therefore, the costs of these are deducted in full when we calculate the value added and, hence, the RR. Thus, these input factors cannot be considered in the same way as purchased equipment that is used repeatedly to "assemble" the finished product.

In addition, aquaculture companies are not obliged to capitalize investment costs in fish in the sea, but can charge expenses for smolts and feed the same year. Skatteetaten (2021) states in the section on aquaculture that «… the purchase price for live fish and other aquatic organisms acquired during the year can be deducted directly…». A fish farming company will have incentives to choose direct deductions since it will be financially advantageous. We therefore assume that this is the practice followed for tax related purposes. However, we perform a sensitivity analysis in Section 4.2.1 to show the effect of including the value of fish in the sea as capital cost. The value of fish farming licenses is also excluded from the concept of capital. For our objective, it is correct, as it is these licences that give rise to RR as explained in Section 2.

The values of the capital objects in NA are based on the original acquisition values. These acquisition values are then adjusted year by year with a sector-specific, geometric depreciation rate that should reflect the actual loss of value of capital. Below we have reported the most important depreciation rates for aquaculture production:

Table 2. Depreciation rates. Per cent.

Capital object	Before 2003	After 2003
Commercial buildings	3.3	4
Ships and vessels	9.7	10
Vans	20.5	13
Machinery	14,5	20
R&D	20	20

Source: Statistics Norway

Every year t, the capital stock *K* (now including *R&D*) in an industry is defined as follows:

$$(1) \qquad K_t = \sum_k S_{k,t-1}(1-\delta_k) + \sum_k I_{k,t},$$

where $S_{k,t-1}$ is the holding of capital type *k* at the beginning of the period, δ_k is the depreciation rate for capital type *k*, and $I_{k,\,t}$ is the investments in period *t* in capital type *k*. The expression $\sum_k S_{k,t-1}\delta_k$ corresponds to the item «capital consumptions» in our calculations.

To be able to calculate the cost of capital, we must have a measure of what the return on capital (K_t) in the industry would have been applied in an alternative way. The required return on capital is discussed in detail in Ministry of Finance (2012), which deals with socio-economic analyses of public measures. The discussion is based on the capital value model, see e.g. Bøhren et al. (2017). The starting point is that an investor in aquaculture will consider both the profitability of the project and the extent to which the project contributes to the investor's overall risk exposure. The capital value model then gives the following formula for the required return ρ:

$$(2) \ \rho = r^f + \beta(r^m - r^f)$$

where r^f is the risk-free interest rate, r^m is the return on the market portfolio and β is an expression of the project's systematic risk. The systematic risk is the part of the risk that an investor cannot diversify away from.

The recommendation in Ministry of Finance (2012) for public projects with normal risk and a horizon of less than 40 years is to use ρ equal to 4 per cent as the real alternative interest rate. They assume a risk-free interest rate of 2.5 per cent and a risk adjustment of 1.5 per cent. It is not recommended to calculate ρ from project to project. The reason is that both β, i.e. the systematic risk and the return on the market portfolio vary over time. They will therefore be sensitive to the period used as a starting point. On the other hand, the Ministry of Finance (2012) also states that for projects with a high systematic risk, it will be appropriate to use a discount rate that is higher. We will return to that in the sensitivity analysis in Section 4.2.3.

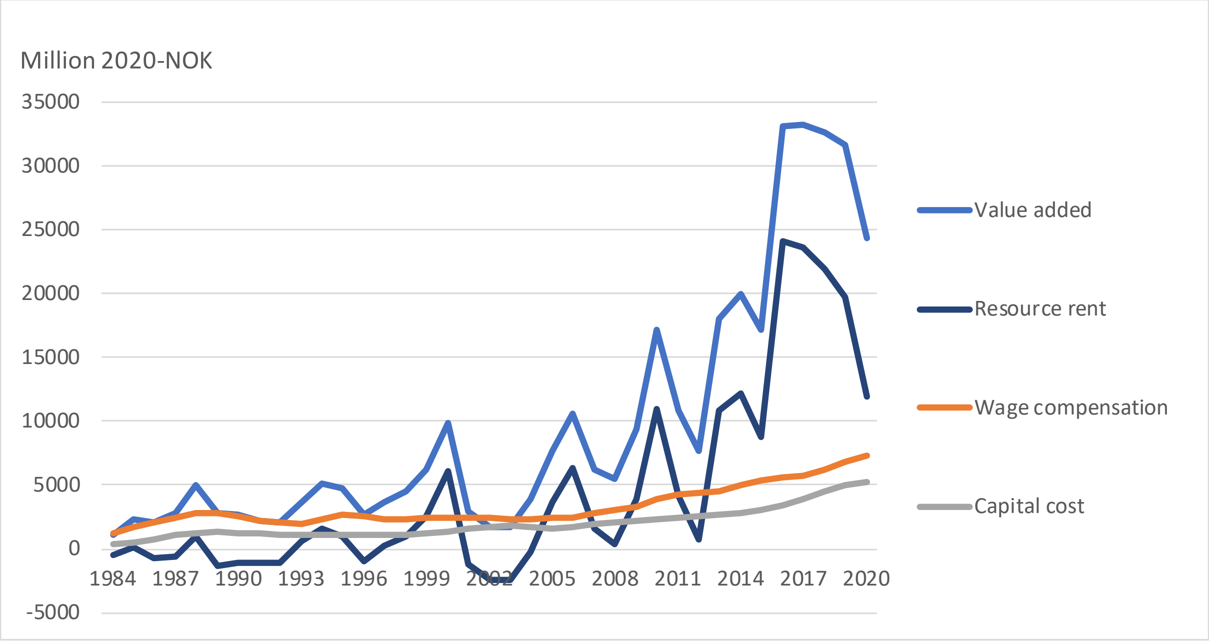
How does this relate to aquaculture? We illustrate the use of the formula for the required rate of return. According to our calculations, the main index on the Oslo Stock Exchange in the period 2000 to 2018 gave an average return of 7.9 per cent. With a 2.5 per cent risk-free interest rate, this implies $\beta = 0.46$ for us to have $\rho = 0.04$. Bøhren et al. (2017) find for 2015 based on weekly data betas of 0.19 for Marine Harvest and -0.33 for Bakkafrost, both of which are aquaculture companies. For the period from 2011 to 2015 based on monthly data, they find betas of 0.67 for Marine Harvest and -0.15 for Bakkafrost. This indicates that the systematic risk in aquaculture is not particularly high. In our basic estimates of the RR, we therefore use $\rho = 0.04$. In our sensitivity analysis in Section 4.2.3 we apply higher rates of return.

4. Resource rent from 1984 to 2020

4.1. Resource rent

All figures have been converted to 2020 prices to measure the purchasing power of the RR over time. The deflator is a weighted average of the ordinary consumer price index and the price index for public consumption. Figure 2 shows a decomposition of the RR in aquaculture for the period 1984 to 2020 based on a required rate of return of 4 per cent.

Figure 2. Resource rent in aquaculture 1984-2020.



At its highest, the RR has been almost 25 billion 2020-NOK. In 2020, when the corona pandemic hit the economy, the RR fell to around 12 billion from 20 billion the preceding year. The RR was not particularly high until the 2000s. For some years in the period 1984-2004 it was even negative. Between 2000 and 2012 it fluctuated sharply. After 2012, the RR has risen markedly, and in the last five years it has been over 20 billion 2020-NOK.[1] We further see that aquaculture is not very capital intensive. Capital costs are less than wage compensation in all years.

Why is the RR rising so sharply from around 2012? The main explanation seems to be increased prices for salmon (and trout). In Figure 3, we compare inflation-adjusted salmon prices from The Directorate of Fisheries with the RR in aquaculture over the period 1994-2020.

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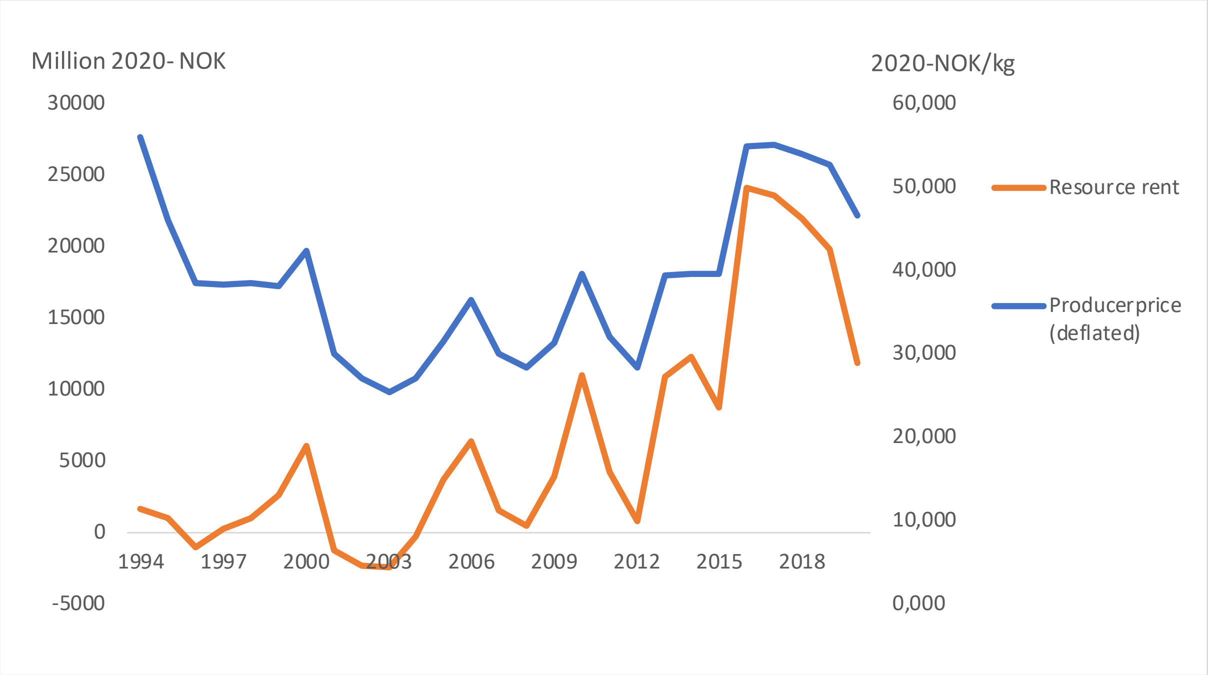
[1] On average from 2000 to 2020, the RR is almost 8 billion 2020-NOK, and then the weak years from 2001 to 2004 are included. Over the last 10 years, the RR has averaged nearly 14 billion 2020-NOK.

Figure 3. Prices on salmon (right axis), resource rent (left axis) 1984-2020.



We see that the RR fluctuates with the salmon price in the period 2000-2020. Furthermore, we see that the increase in the RR from 2012 is related to increased salmon prices. Salmon prices were also high in the 1990s, but then it does not appear that the industry was able to take advantage of this to the same extent. It is reasonable to imagine that this is related to high costs. Production costs (at constant prices per kg of salmon) fell by around 80 per cent from 1991 to 2000 (Eikaas, 2011). The relation between the RR and the price of salmon seems to be stronger as the years go by; the correlation coefficient for the entire period is 0.73, while for the period 2000-2020 it is 0.98.

4.2. Sensitivity analysis

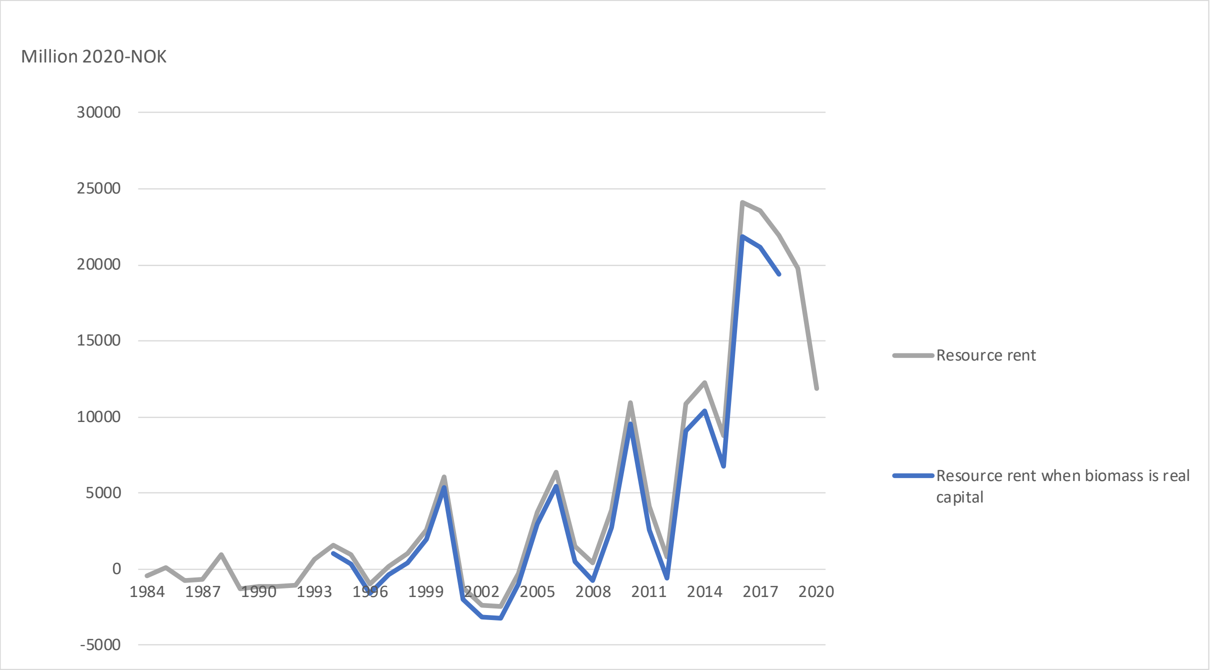
4.2.1. Fish in the sea as capital cost

Our assessment of the potential importance of including the biomass of the fish in sea in the real capital stock is based on the following formula:

$$(3)\ Biomass_{t-1} = 0.75 * Fish\ sold_t * variable\ costs_{t-1}$$

The volume of fish sold in a year is estimated to be around 75 per cent of the volume of biomass the preceding year over the period 1984-2018. We apply the variable costs from The Directorate of Fisheries (2021) to get the value of biomass. We see from Figure 4 that the RR necessarily is lower when we include biomass as capital costs. In the years 2016-2018 the difference averages 2.4 billion 2020-NOK (which equals a 10 per cent reduction).

Figure 4. Resource rent in base case scenario and when we also include biomass is real capital. 1984-2020.

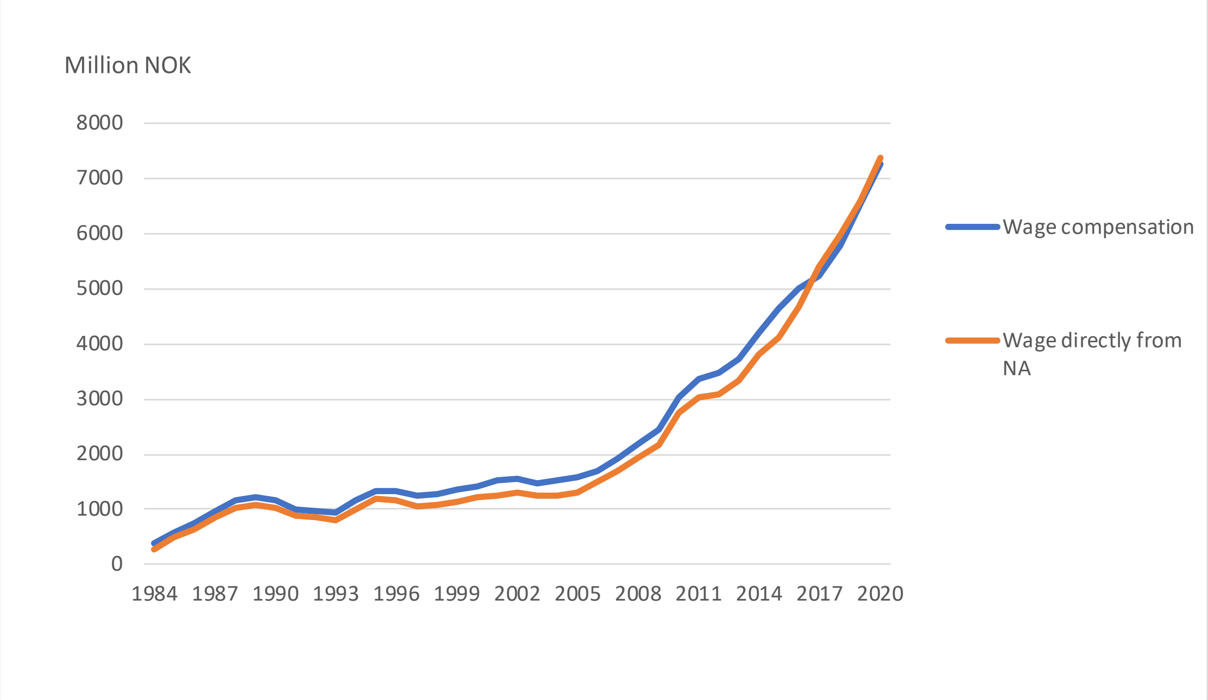


The NA include costs for smolts as intermediate inputs. Alternatively, the outlay for smolts can be capitalized and depreciated through capital costs as we have done here. However, one cannot have both directly registration of expenses as well as calculation of capital costs, since this will give double counting. According to The Directorate of Fisheries the costs for smolts in aquaculture were around 4.8 billion NOK (2020-NOK) from 2016 to 2018, around the double of the value of the biomass. Hence, deduction of the value of smolts through capital costs instead of intermediates leads to higher RR. In Section 4.2.3 we return to this calculation applying a higher rate of return for both real capital and biomass.

4.2.2. Wage compensation

Figures 5 shows the development in wage costs in aquaculture, calculated in two different ways: 1) The hourly wage rate for mainland Norway multiplied by the total hourly wage for both employees and the self-employed in the industry, as done above; 2) use actual wage costs as they appear in aquaculture in NA, but only for the employees and not the self-employed. We see from Figure 5 that for aquaculture, actual wage costs are generally 10-20 per cent below the estimated wage compensation (but the last four years they have been marginally higher). This may reflect that the level of education of those who work in aquaculture is (or has been) relatively low, so that the average wage per. hours for mainland Norway is too high for this industry.[2] As the figures show, there are relatively small differences between the two ways of calculating wage costs and in addition wage consumption is only a small part of the RR as Figure 2 shows. Hence, we do not perform new calculations of the RR.

Figure 5. Wages in aquaculture 1984-2020.



4.2.3. Capital cost

To check the robustness of our RR estimates, we apply alternative rates of return. We use the real rates of return to capital in market-oriented mainland industries reported in Statistics Norway (2021). These current rates are calculated by dividing the operating profit for the sectors by the capital stock in the sectors. The operating profit is calculated as the profit after both capital depreciation and a hypothetical remuneration to the self-employed are included.

In Figure 6, the category «market-oriented mainland industries» includes all private enterprises except oil and gas extraction and housing services. Manufacturing is thus a subcategory of this. As we see

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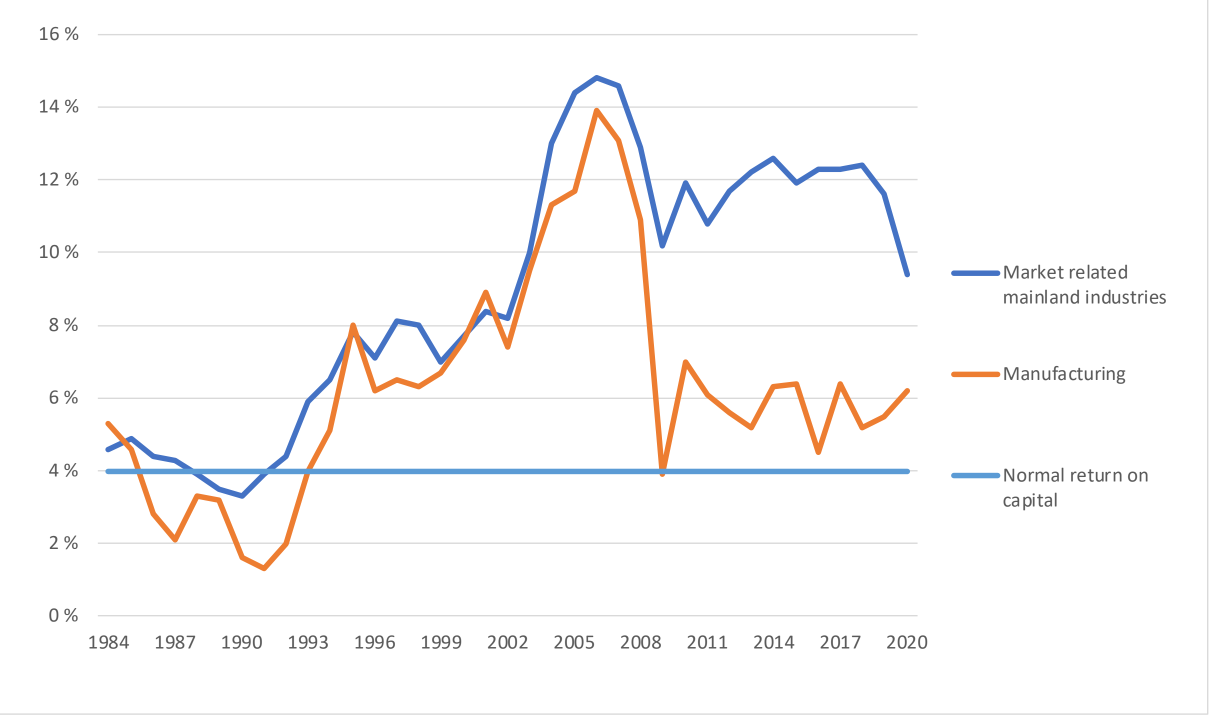
[2] According to SINTEF (2018), there is a lot of foreign labor in aquaculture and they earn around 20 per cent less than Norwegian workers.

from Figure 6, the actual return on capital has exceeded the estimate we use for the normal return in most of the years we have included in our analysis. This may be due to problems in determining the value of the capital stock in service industries such as the financial sector and the consulting sector (these are part of market-oriented mainland industries). Furthermore, bankruptcies will not be properly represented as the operating profit is set at zero in the event of a bankruptcy, and the losses suffered by investors are not considered. In any case, we present alternative figures for the RR, where we use actual returns for manufacturing and mainland industries. We emphasize that applying higher discount rates than in our base case are appropriate for projects with e.g. a high systematic risk.

Figure 6. Actual return on capital in the Norwegian economy 1984-2020.



Source: Statistics Norway (2021)

The Ministry of Petroleum and Energy uses a 7 per cent real interest rate in the assessment of the so-called "Plan for development and operation (PDO)" for new oil fields.[3] We have therefore also made calculations of the RR with a 7 per cent return on capital for aquaculture.

Figure 7 shows that our RR estimate is relatively robust to the choice between the three rates of return. As aquaculture is not very capital intensive, it seems reasonable to use the return on capital in

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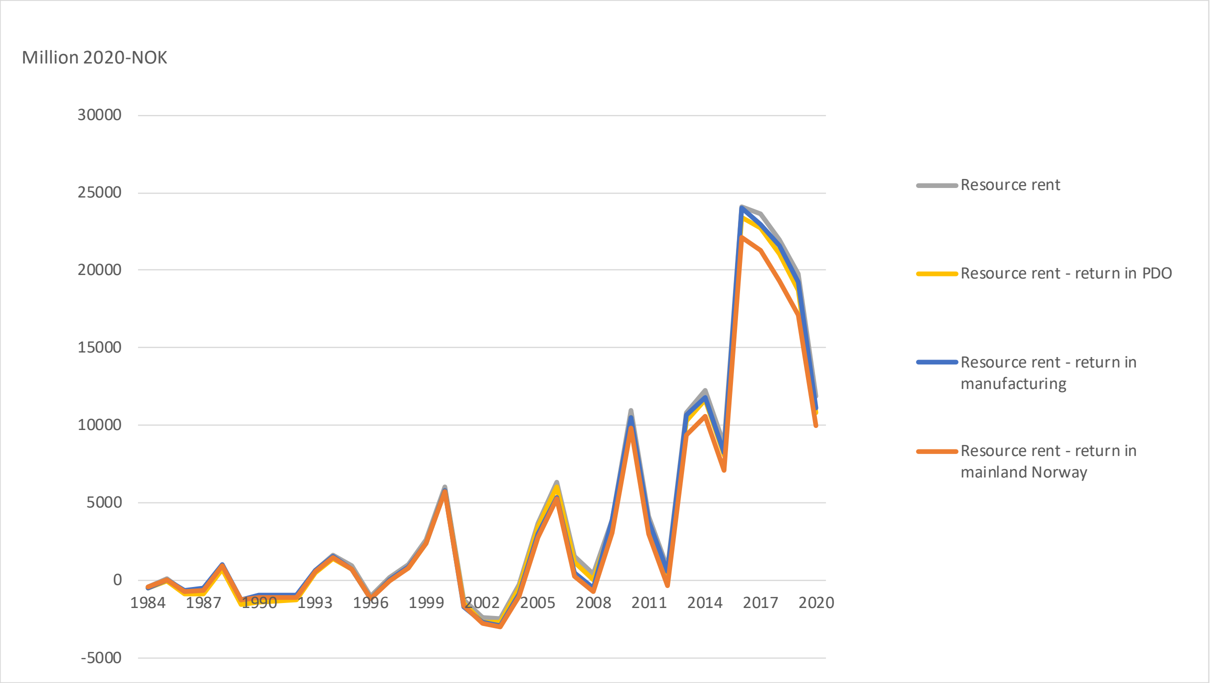
[3] See e.g. Prop 80 S (2017-2018) to the Parliament on the development and operation of the Johan Casterberg field.

mainland Norway as an alternative cost for capital in the industry compared to our base case scenario. The RR declines from around 20 billion NOK to 18 billion in the last five years with an average rate of return of mainland Norway. The average RR is 6.5 billion NOK for the years 2000 to 2020 with the mainland return, down from 7.8 billion in the base case.[4] The average rate of return in mainland Norway was around 12 per cent over the period 2000-2020. Hence, this rate of return in this period is somewhat higher than in Misund et al. (2019), who suggest a rate of return of around 10 per cent for a fish farming company.

Figure 7. The resource rent with different required rates of return 1984-2020.



As was explained in Section 4.2.1, the average costs for smolts in aquaculture were around 4.8 billion NOK (2020-NOK) from 2016 to 2018. In Section 4.2.1 we calculated the capital value of smolt with a 4 per cent discount rate and got a higher RR than when we valued the smolts as intermediates. If we apply the return in mainland Norway for all capital including the value of biomass of smolt in the period 2016-2018, the RR is now around 10 per cent lower compared to the situation where we deduct the costs of smolts directly. Hence, to include the stock of fish in the sea as capital does not lead to a large reduction in RR.

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[4] On average from 2000 to 2020, the RR in the various sensitivity scenarios is around 6.5-7.3 billion, and then the weak years from 2001 to 2004 are included. If we look at the last 10 years, the RR has averaged around 12-13 billion with the various alternative required rates of return.

5. Conclusions

Revenue from natural resources is related to the term resource rent. The resource rent is the income that can be attributed to a natural resource. It is measured as the residual profits when all necessary input factors have received their remuneration. There are only a limited number of locations worldwide and in Norway which is suitable for aquaculture activities and this give rise to resource rent. Good localities depend, among other things, on climatic conditions, qualities of seawater and protection from weather and wind. As with other natural resources, limited access in aquaculture can also be considered as the result of the interaction between resource scarcity and regulations in the form av a limited number of licenses. Furthermore, limited access may limit the output of fish, thereby increasing the price compared with that of perfect competition and lead to market rent.

The starting point for calculating the resource rent is that production of a natural resource can be expressed by a production function, where one or more ecosystem services are included as input factors. If we know the remuneration of all input factors such as capital, labour and technology except the remuneration of the aquacultural services, the resource rent will appear as the difference between the value of output and the remuneration of all other input factors. Introducing the return on real capital including *R&D* expenses as well as labour costs, we argue that we to a large extent are able to separate between the contribution to output from aquacultural services and other input factors. We also argue that the value of fish farming licenses should be excluded from the concept of capital, because for our objective it is these licences that give rise to resource rent.

Based on data and definitions in the National Accounts and the System of Environmental-Economic Accounting we calculate the resource rent in aquaculture in Norway in the period 1984-2020. On average from 2000 to 2020, the resource rent is almost 8 billion, and then the weak years from 2001 to 2004 are included. After 2012, the resource rent has risen markedly. If we look at the last 10 years, the resource rent has averaged around almost 14 billion. In the last five years it has been over 20 billion NOK and then we include 2020, when the corona pandemic hit the economy and the resource rent fell to around 12 billion from 20 billion.

We perform various sensitivity analysis as introducing higher rates of return, applying alternative wage costs and treating the stock of fish as real capital. This does not change the conclusion that there has been a significant resource rent in aquaculture since 2000 and that it has risen markedly since 2012.

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