RENTS AND RENT TAXATION
IN NORWEGIAN AQUACULTURE

Preliminary report

Prepared for Seafood Norway

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by

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Hagrannsoknir sf.

PREFACE

On January 10 2020, Hagrannsoknir sf. signed a contract with Sjømat Norge to conduct a study of economic rents and taxation as pertains to salmon aquaculture in Norway with special regard to the recent report NOU 2019: 18 Skattlegging av havbruksvirksomhet, According to this contract, a preliminary report was to be submitted on January 31.2020. This report is to meet that contractual obligation.

On behalf of Hagrannsoknir, professors Ragnar Arnason and Trond Bjørndal have prepared this preliminary report.

For Hagrannsoknir sf

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EXECUTIVE SUMMARY

A recent white paper, NOU 2019: 18 *Skattlegging av havbruksvirksomhet* (hereafter the Report), prepared by a commission tasked with assessing taxation of aquaculture, claims there are “rents” in Norwegian salmon and trout aquaculture and proposes the introduction of a “resource tax” so that society at large will receive a larger share of the value-added created by this industry. From the point of view of economic theory, as well as knowledge about the industry and market structure, we analyse whether the claims in the Report are valid.

The report defines “renprofit” as supernormal profits ("extraordinær avkastning") and attributes them to superior natural resources (“naturgitte fortrinn”) and regulations. It then proceeds to equate "renprofit" with “grunnrente”. The main argument for this terminology seems to be that this is often done, although no references or evidence to this effect are provided. In various other places in the Report, it is claimed that natural resources (marine sites) explain a significant part of the "renprofit" or "grunnrente".

In economic theory, economic rents and economic profits are two different concepts and in quantitative terms, they are generally not equal. In “well-behaved” situations, rents would be smaller than variable profits with the difference being so-called infra-marginal profits. It follows that what the Report calls "grunnrente" is not at all economic rent. Moreover, since "grunnrente" is not economic rent it cannot be assumed to exhibit the special properties that are often associated with economic rents, as suggested by the Report.

The Report repeatedly attributes "renprofit" to the natural resources used in aquaculture. However, the profits are the result of all the variables that enter the profit function of the aquaculture firms including management, labour, technology, innovations, feeding, transportation and so forth. It is all these factors in combination that generate the profits. Moreover, they are all necessary for positive profits in the sense that a minimum amount of all of them is required to obtain these profits.

Accordingly, it is misleading to refer to the profits in Norwegian salmon aquaculture as economic rents and even more misleading to refer to them as natural resource rents. This can also be said about the studies by Greaker and Lindholt (2019) and Flåten and Pham (2019) that the Report uses as “evidence” for the existence and magnitude of rents. The estimates these reports present are measures of profits, not rents. Moreover, they disregard the existence of infra-marginal profits. As these are believed to be fairly substantial in this industry, this is a major oversight. Moreover, the opportunity costs of permit values and the stock of fish is not taken into account in the estimation of profits. This means that their estimates of economic profits are seriously misleading.

According to the Report, pure profits in Norwegian aquaculture are partly a “classic” rent as the number of sites suitable for aquaculture purposes is limited at the world level. They also state that they are partly a regulatory rent, as the number of permits in aquaculture is limited for environmental reasons. The assertion that the number of suitable sites at the world level is given and acts as a constraint on the development of the industry is in our mind at best a hypothesis but, as far as we can see, the Report presents no evidence that this is in fact true. We dispute this hypothesis and assert that, provided environmental constraints are met, there is ample site availability for the expansion of salmon aquaculture in both Norway and elsewhere.

While permits were originally awarded for free, since 2002, there have been charges for increases in production capacity, be it increases in maximum allowable biomass (MTBs) or new permits. This has been at fixed prices or by auction, or a combination of the two, as in 2018. Over the years, there has been trade in permits or perhaps more so, buying and selling of firms that own permits. As a consequence, permit values have been capitalised in the accounts of firms in the industry. A new tax will reduce the value of existing permits in the industry, i.e., reduce asset values, a fact that is not considered in the Report.

A majority of commission members recommend the introduction of a profit based “rent” tax on the aquaculture industry. Arguments put forward for this recommendation include that such taxes are used in certain other natural resource-based industries such as petroleum and hydro-electricity, the natural resources used belong to the nation and that natural resources used such as sites are immobile and cannot be moved to other nations.

It is clear that what is being recommended by the majority, represents a profit or an extra income tax; there is no way this can be called a rent tax. The majority recommend the introduction of a 40% tax rate which may bring an annual government revenue of NOK 7 billion.

The Report gives the impression that this will be a permanent revenue to the government, without considering whether the current high profits are a transitory phenomenon in an industry that is still being globally expanded. The Report seems to assume that the aquaculture industry is in equilibrium. In a fast growing industry, not least one that is based on great technological advances like salmon aquaculture, profitability tends to very high. Indeed, the industry is fast growing because the profitability is high. The social function of this high profitability is to signal to economic agents to bring new entrants and capital into the industry as fast as is economical so the people can enjoy the fruits of the technological advance to the greatest possible extent. However, as the opportunities of the new technology are gradually exhausted and increased supply catches up with the demand, profits tend to decline and converge to normal profits. The salmon aquaculture industry may well an example of this process. If that is the case, the current high profitability in Norwegian aquaculture is passing through a high profits disequilibrium phase which in due course will converge to normal profitability equilibrium as the global supply expands and close substitutes are developed. In this case, the currently high profits have very little to do with the natural resources given by the aquaculture sites used by the industry and, therefore, do not provide a reason to impose special taxation on the industry. In fact, special taxation may easily reduce Norwegian share of the market and global profits during this transient economic phase.

According to the Report, a properly designed rent tax will be economically neutral. This implies that there will be no economic distortions. The use of inputs will be unchanged in spite of the tax, investment projects that are profitable without tax will also be profitable with the tax, entry into and exit from the industry will be unaffected by the tax, the business risk of aquaculture operations will be unchanged and so on and so forth. We do not think this is true. Moreover, as far as we can see, there is no reference in the Report to the consequences of taxation of infra-marginal rents. It is well established in the literature that taxes on infra-marginal profits will be economically distortionary.

We find, that contrary to what is asserted in the Report, a tax on aquaculture rents is economically distortive. The Report argues that because the marine sites used by aquaculture are immovable natural resources they cannot be affected by the proposed taxation. This argument, however, misses the crucial point that many other production inputs are controllable by the aquaculture companies and these will inevitably be adjusted so as to maximise the retained profits, i.e., profits net of taxation. Taxation of economic rents in salmon aquaculture is likely to affect the use of flow inputs such as feed as well as the timing and length of the production cycles (rotation), the extent and composition of investments, entry and exit decisions and so on. Moreover, to the extent that profitable production sites are available in other countries, special rent taxation may lead to more of the industry being placed abroad.

It is also the case that a special tax will spur the development of alternative technologies. Some of these, such as land based, are likely to be located in or near large consumer markets. This would not only cause a reduction in Norwegian market share, but also lower the value-added generated and very likely also reduced profitability.

A key rationale for the report's proposal of a special tax on aquaculture profits is to generate more government revenues. However, rent taxation is economically distortive. Therefore, its imposition will reduce the value-added in the aquaculture industry. Moreover, through supply chains, it will also lead to distortion in other industries and thus likely also reduce their value-added. Through distorted investments, these impacts will become more pronounced in the long run. For these reasons, it is not at all clear that the special taxation on salmon aquaculture proposed will actually increase government taxation revenues. There are two opposing impacts at work here: A higher tax rate will increase government revenues; reduced value-added due to the distortive impacts of the taxation will reduce it. Therefore, the net outcome, both in the short and long run, is a matter of empirical investigation. This investigation is not undertaken in the Report.

1. INTRODUCTION

The purpose of this report is to undertake an analysis of rents, infra-marginal profits and profits as pertains to aquaculture. A recent white paper, NOU 2019: 18 *Skattlegging av havbruksvirksomhet* (referred to as NOU in this introduction), prepared by a commission tasked with assessing taxation of aquaculture, claims there are “rents” in Norwegian salmon and trout aquaculture and proposes the introduction of a “resource tax” so that society at large will receive a larger share of the value-added created by this industry. From the point of view of economic theory, as well as knowledge about the industry and market structure, we will consider whether and to what extent the claims in the NOU are valid.

This report is organised as follows. In section 2, we provide a brief evaluation of issues in the NOU that are of particular relevance to rents and rent extraction. This is followed by an overview over regulations of aquaculture in section 3. The theoretical essentials relating to economic rents are discussed in section 4, while this theory will be applied to Norwegian aquaculture in section 5. Whether rent taxation is economically distortive, is addressed is section 6. Section 7 gives an evaluation of certain rent studies and estimates relating to Norwegian salmon aquaculture that are used in the NOU. Major weaknesses in the NOU report are highlighted in section 8.

2. OVERVIEW OF NOU 2019: 18

As noted above, NOU 2019: 18 is a white paper prepared by a commission with the task of assessing taxation of aquaculture. It is a very extensive report that examines a large number of issues. In this section we will provide a brief overview of issues raised in the report that are particularly relevant when it comes to rent and rent taxation. We will summarise some of the points and proposal, to be followed by our evaluation.

1. Rent and profits. According to the NOU, pure profits can be attributed to a number of causes, such as site specific resources, government regulations, market power and more. According to the NOU, the concept of rent ("grunnrente") is often used as a common term for all sources of pure profits.
   This use of the concept of rent is not in accordance with economic theory, as we will explain in section 4.
2. According to the NOU, pure profits in Norwegian aquaculture are partly a "classic" rent as the number of sites suitable for aquaculture purposes is limited at the world level. They also state that they are partly a regulatory rent, as the number of permits in aquaculture is limited for environmental reasons.
   The assertion that the number of suitable sites at the world level is given and acts as a constraint on the development of the industry is in our mind a hypothesis but, as far as we can see, the NOU presents no evidence that this is in fact true. We will address this in section 3.
3. The concept of infra-marginal profits is not discussed in this report. This is a major oversight that will be considered in several sections of this report.
4. Two economists were commissioned to estimate rent in aquaculture and other resource industries; this is published as Greaker and Lindholt (2019). The NOU also makes reference to Flåten and Pham (2019) and considers tax data and prices obtained in the 2018 auction of aquaculture permits. The NOU states that there is substantial rent in the industry, however, without attempting to attribute what they call rent to a constraint on the number of sites and regulations, and without trying to assess infra-marginal profits.
   We have evaluated the reports by Greaker and Lindholt (2019) and Flåten and Pham (2019) in section 7.
5. As described in section 3, permits were originally awarded for free. Since 2002, the government introduced charges when new permits were awarded – increases in production capacity, be it increases in maximum allowable biomass (MTBs) or new permits, are awarded at fixed prices or by auction, or a combination of fixed price and auction as in 2018.

According to the NOU, about 80% of all permits have been awarded for free. Moreover, it is stated that the total permit value in the industry may be in the range NOK 200 billion, while the industry has paid in total only about NOK 6.8 billion to the government, or 3% of the total value.

Over the years, there has been trade in permits or perhaps more so, buying and selling of firms that own permits. This has, of course, been at market price.which means that permit values have been capitalised in the accounts of firms in the industry. Moreover, permits have been traded in the expectation that there will be no major changes to the current tax regime[1]. A new tax will reduce the value of existing permits in the industry, i.e., reduce asset values, a fact that is not considered in the report.

6. According to the NOU, a properly designed rent tax will be neutral. This implies that there will be no economic distortions: investment projects that are profitable without tax will also be profitable with tax.

   As far as we can see, there is no reference in the NOU to the consequences of taxation of infra-marginal rents. It is well-known in the literature that taxes on infra-marginal profits will be distortionary. In addition, there is also growing theoretical evidence that taxes on economic rents are also distortionary.

   The distortionary effects of rent taxation will be analysed in section 6.

7. A majority of commission members recommend the introduction of a profit based "rent" tax on the aquaculture industry. Income should be based on the value of fish taken out of the sea-pens. As there is no market price for fish at this level of the value chain, it is suggested that "norm prices" be used. To assess "rent", production costs will be deducted as well as depreciation. There will also be a deduction for an "uplift", an interest compensation for the fact that investment costs are not deductible when incurred, while deductions take place over time through depreciation charges. On the other hand, there will be no depreciation of permits, as they are of infinite duration.

   The majority recommend the introduction of a 40% tax rate which may bring an annual government revenue of NOK 7 billion. The report gives the impression that this will be a permanent revenue to the government, without considering whether high profits are a transitory phenomenon in an industry that is still in expansion.

8. A minority of members recommend continuation of the present system of special taxation of the industry though the sale of new production capacity (permits and extensions of MTB

[1] There may be an exception when it comes to permits auctioned in 2018, at which time it was known that special taxation of aquaculture was being considered, albeit without knowledge of how and at what rate.

capacity). In the case of no growth in the industry, they also recommend the introduction of a production fee.

As mentioned, the NOU also presents numerous other recommendations, e.g. how tax revenues should be shared between the central government and municipalities. Although we fully recognise the importance of such considerations, we will, in this report, concentrate on more principled matters relating to rents and taxation.

3. REGULATIONS OF SALMON AQUACULTURE

In this section, we review current regulations of aquaculture in Norway and aspects of the production process that may give rise to economic rents.

3.1 Background

Since the 1980s, salmon farming has been one of the fastest growing food industries in the world (Asche and Bjørndal, 2011). However, the annual world production has levelled off in recent years, at about 2.3 million tonnes during 2013-16. Norwegian production has similarly levelled off since 2012 at about 1.2 million tonnes per year, or slightly less than 60% of the global production (Bjørndal and Tusvik, 2019). In 2017, the most recent year for which statistics are available, world production of salmon was 2.24 million tonnes, with Norway producing 1.24 million tonnes.[2]

Helped by increasing demand for salmon worldwide, salmon farming is a profitable industry (Brækkan *et al.*, 2018). However, for the past few years, production growth has been limited in both Norway and Chile, the two major producers, apparently for the most part due to increasingly restrictive government regulations designed to meet environmental challenges in sea-based salmon aquaculture. In other countries such as Canada[3], the Faroe Islands and the UK, limited access to new production sites, also primarily for environmental reasons, appears to be a constraint on expansion.

Compared with the industrial norm, profitability in salmon farming has recently been good although highly variable when a longer time perspective is considered. Thanks to increasing demand, the price-cost margin has also increased in recent years despite a fairly substantial increase in the cost of production since 2012 (Bjørndal and Tusvik, 2019). This state of affairs usually leads to a rapid increase in production. The reason this has not happened, seems primarily to be environmental constraints limiting expansion in both Norway and Chile.

In Norway, the main problem is sea lice which causes higher mortality, albeit often indirectly through treatment, lower harvest weight and diminished quality of harvested fish. Presently, this seems to be the most pressing environmental issue for the industry. In addition to the impact on farmed salmon production, salmon lice originating from sea pens are currently seen as the main threat from salmon farming to the wild salmon population (Misund, 2019). Biological sustainability has become the major concern for the industry, and it now acts as a significant constraint on increased production (Hersoug *et al.*, 2019).

[2] These figures do not include sea trout and salmon other than Atlantic.
[3] Canada's prime minister has signalled that he wants to phase our sea-based salmon farming in British Columbia by 2020. See https://salmonbusiness.com/trudeau-officially-sets-mandate-to-end-bc-salmon-farms-by-2025/

3.2 Regulations

A government permit[4] is needed to establish a sea-based salmon farm (Asche & Bjørndal, 2011). The number of permits is regulated by the government. Over the years, there have been different justifications for controlling the number of permits such as promoting economic development in coastal regions. Up to 2002, permits were awarded free of charge. More recently they have been auctioned by the government. The last auction was in 2018. The next may be held this year (2020), but to the best of our knowledge no plans for this have yet been made public.

Over the years, the production capacity of permits has been regulated in different ways such as pen capacity measured in cubic metres (Asche and Bjørndal, 2011). Currently, production is constrained in the form of a regulation of standing biomass given by a Maximum Permitted Biomass (MTB) per permit. A "standard permit" has an MTB of 780 tonnes[5], however, many firms have been able to secure additional capacity so that many permits now have a higher MTB than this (see below). This regulation implies that actual biomass must never exceed the MTB[6][7]. A company may have several permits and, within a given production area, the total standing biomass must not exceed its total MTB for the area.

Permits are allocated to production areas. The coast of Norway, from the border with Sweden to the border with Russia, is divided into 13 different production areas[8]. These production areas are fairly large, and it is possible to move a permit from a site in one area to an approved site somewhere else within the same area. When it comes to moving permits between production areas, this is far more complicated and happens only to a limited extent.

Production sites for sea-based aquaculture are approved in a process involving both local and central authorities. Permitted production per site depends on an environmental feasibility study. The sites also come with an MTB which must also not be exceeded. Often, a site can accommodate several permits, however, the MTB of a permit can also be split between two or more sites. It is also important to note that a company usually has more production sites than permits due to the fact that after a production cycle, a site needs to be fallow for a period of time.

[4] Previously, the government issued salmon farming licenses. The terminology has now changed, with the term *permit or permission* having replaced license.
[5] The MTB is 945 tonnes per permit in the counties of Troms and Finnmark.
[6] This regulation is often misunderstood: a farmer must harvest so that the standing biomass never exceeds this constraint. This means that the farmer will every month harvest "excess growth". Thus production will normally be higher than the MTB. In 2017, production was 1.83 tonnes per tonne MTB, while was reduced to 1.57 tonne in 2017. This is for the industry as a whole, where production is measured as sales plus fish for destruction plus changes in the stock of fish, based on the biomass registry of the Directorate of Fisheries (source: R. Dahl and J. Idsø, private communication).
[7] NOU 2019:18 makes the erroneous assumption that annual production is equal to MTB (box 7.3, page 166).
[8] https://www.fiskeridir.no/Akvakultur/Tildeling-og-tillatelser/Kapasitetsjustering-trafikklyssystemet/Implementering-av-produksjonsomraader-2017

During the period 2012-18, average production per site was 2,235 tonnes, varying between 2,000 tonnes in 2012 and 2018, while it was just over 2,400 tonnes in 2015 and 2016.[9] According to the Aquaculture Registry, 1,033 sites are approved for sea-based production of salmon and trout. In 2019, 581 sites were in use. A site may lie fallow for two years before it is withdrawn and many firms rotate the use of sites. Although we have not investigated the matter in detail, these numbers nevertheless indicate that sites are available for further expansion of the industry, if and when that should be permitted.

As noted, the scope for expansion in sea-based salmon aquaculture is currently limited. Thus, to enter the industry, an existing permit needs to be purchased. As a consequence of good profitability, limited scope for expansion and no new licenses being awarded, the value of sea-based permits is high.

The sea lice problem is addressed in different ways; in addition to preventive action such as the use of wrasses, there are chemical as well as non-chemical treatments including fresh water and hot water baths, and mechanical treatments such as hosing and brushing. Nevertheless, treatments often cause reduced growth, higher mortality and reduced fish quality.

Sea lice infection on salmon farms has been subject to regulations since 1997 to reduce the harmful effects of lice on farmed and wild fish (Abolofia *et al.,* 2017). Regulations set thresholds for the maximum mean number of sea lice per fish (lice count) and a compulsory reporting system is in operation. If the legal lice infection threshold levels, enforced by the Norwegian Food Safety Authority (NFSA), are exceeded it is mandatory for the farmer to medically treat or slaughter their fish within two weeks (ibid.).

A new production capacity adjustment system was implemented from October 1st, 2017 (The Norwegian Government, 2017). The intention is to ensure the sustainable growth of the industry, with future growth to be granted based on sustainability indicators, which are currently sea lice. Labelled the "traffic light system", the regulatory system assigns the codes green, yellow or red to each area of the 13 production areas depending on their performance with regard to the predefined environmental criteria set by the government (IMR, 2015). Based on assigned codes, each production area may be allowed to increase its production (green light), freeze its production (yellow light) or be required to reduce its production (red light). If the environmental criteria are satisfied within a region, the region can grow by a maximum of 6% for every two-year period – a quantity which is to be distributed between existing and new permits (The Norwegian Government, 2015a; Intrafish, 2017b).

[9] Production measured as harvest plus removal of dead fish adjusted for changes in the stock of fish. Source: R. Dahl and J. Idsøe, private communication.

Thus, the producers are encouraged to take responsibility for the area in which they produce, and good practices and routines may be rewarded with a permission to expand production (Nrk.no, 2017).

Thus, depending on environmental conditions, existing producers may be permitted to increase their capacity. This happened in 2018 with a 6% increase production capacity measured as MTB in "green areas".[10] For a 2% increase in production capacity the government set a fixed price of NOK 120,000 per tonne MTB which translates into NOK 93.6 million for a "standard" 780 tonne permit. In addition, another 4% of production capacity were auctioned off at prices varying between NOK 132,000/tonne and NOK 252,000/tonne[11], implying a "standard" permit value between NOK 102,960 – 196,500 million.[12] The extra production capacity was mainly used to increase the MTBs of existing permits although some new permits were also issued.

The companies are subject to numerous other regulations, many of a more technical nature, that we will not go into, except for one. Smolt may be considered an "essential" input in salmon farming. Until 2012, regulations stated that hatchery-reared salmon should not have a weight exceeding 250 g before being transferred into traditional sea cages. As of 2012, however, holders of hatchery permits have been allowed to produce smolts with a weight of up to 1,000 g (Hagspiel *et al*., 2018). This makes what is known as post-smolt production possible: as the smolts are kept in freshwater longer, time spent in seawater can be reduced. This will lead to a reduction in total mortality as the time in seawater is the part of the production cycle that is most prone to lice and disease. A longer freshwater phase also means that farms may save one or more costly delousings, depending on the circumstances.

An important objective in a firm's production plan is the optimal use of production capacity. Under the current regulatory and market conditions, the main focus of the companies is on maximising production per permit.

3.3 Technological development

Where binding constraints (e.g. due to regulations) prevent expansion of a profitable industry, economic agents have an incentive to develop processes and technologies in order to counteract or overcome the constraints. This is very much the case for salmon farming, where at least three avenues for expansion can be observed. The first avenue is that of moving to offshore farming including the development of closed or semi-closed farming systems (Bjørndal, Holte, Hilmarsen and Tusvik,

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[10] One could also apply for increases in production capacity in yellow and red areas, however, more stringent rules apply. See https://www.fiskeridir.no/Akvakultur/Tildeling-og-tillatelser/Kapasitetsjustering-trafikklyssystemet.

[11] See https://www.fiskeridir.no/Akvakultur/Tildeling-og-tillatelser/Auksjon-av-produksjonskapasitet/Auksjon-juni-2018.

[12] As this price is for an increased production capacity in an already established operation so that set-up and investment costs are probably minimal, this number probably overestimates the price of an entire licence.

2018). Among other things, this development is supported by the awarding of so-called "development" permits that involve substantial technological innovation for free.[13]

Another avenue for expansion is the development of land-based salmon farming, as analysed by Bjørndal and Tusvik (2019). Currently, there are two competing land-based production technologies, Recirculating Aquaculture Systems (RAS) and flow through systems, where RAS appears to be the solution preferred by the industry. The main advantage of RAS is the ability to maintain optimal water quality with less use of expensive energy than if the water was not recycled (Bjørndal and Tusvik, 2019; Hagspiel *et al*., 2018). Over time, there have been technological developments in land-based production and improvements in relative cost competitiveness that under given conditions might also make this technology economically feasible. A further advantage of land-based facilities is that they may more easily be located in or near major consumer markets providing savings on transportation costs compared to suppliers in Norway and Chile. Locating land-based facilities in the consuming country may also involve other advantages such as the avoidance of import duties.

A third avenue of development in production technology is extending the fresh water phase of the production cycle that was discussed above. Instead of releasing smolts of 100-150 g for on-growing in sea-cages, as has been the norm for a long time, the fresh water phase is lengthened to produce what is called post-smolts of up to 1,000 g before release into sea-water (Bjørndal and Tusvik, 2020; Hilmarsen *et al*., 2018). The use of post-smolts is of interest for two reasons: (i) it reduces production losses (i.e., due to increased mortality and reduced growth because of sea lice infection) and (ii) it increases the ability to make full use of the MTB, if access to sites or coordinated fallow periods represent a binding constraint. Longer production period in freshwater means that the sea water phase is correspondingly reduced with less exposure to sea lice. There are many indications that this mode of production will become increasingly important in the future.

3.4 The production process in salmon aquaculture

Bjørndal (1990) describes the production system in salmon aquaculture as a physical system (technology) interacting with a biological system (growth and mortality, feeding) within an environmental system (sites, wind and wave action, temperature). Realised production depends on the interactions between these three parts of the system, which are also greatly affected by the official regulatory system. This complexity suggests high intra-marginal profits as part of the profits at each site. There is also empirical evidence to this effect.

[13] See https://www.fiskeridir.no/Akvakultur/Tildeling-og-tillatelser/Saertillatelser/Utviklingstillatelser.

As illustrated e.g. by Dahl and Idsø (2017) and Asche and Sikveland (2015), there is great variation in profitability between salmon firms. As price differences tend to be limited and the variation in the quality of sites between companies is not great, this is largely due to differences in company efficiency, i.e. variations in the cost of production. In fact, this is evidenced by the annual cost and earnings studies undertaken by the Directorate of Fisheries, which show substantial differences between farms when it comes to average cost of production per kg of salmon.[14]

As realised production depends on interactions between the different parts of the production system, as well as management, it is likely that this may give rise to various types of infra-marginal profits, i.e., that part of profits that cannot be classified as rents (see chapter 4 below). Note however, that as we are talking of a highly complex system, it appears virtually impossible to determine the impact of individual factors on infra-marginal profits.

Special mention must be made of the aquaculture environment, i.e. the sites at which the salmon farming takes place. Different sites are characterised by differences in environmental conditions such as wind and wave action, water depth currents and salinity, and temperature variation over the year. As in agriculture, where some land is more productive than other, some sites are likely to be more productive than others – *ceteris paribus.* These differences in environmental conditions are likely to give rise to a site specific or locational rent.

As noted above, the coast of Norway is now divided into 13 production regions. Substantial differences in cost of production between the different regions (counties) can be observed. These differences are undoubtedly due to many factors, including local economic infrastructure, differences in efficiency between the firms in each region and different environmental conditions in each region.[15] As we can only observe the combined impact of all of these factors on profits it is difficult to determine the contribution of each one of them.

3.5 Regulatory rent

As discussed above, salmon aquaculture is subject to a set of regulations that directly affect production processes in various ways. Moreover, the quantity of production is clearly constrained by current regulations.

The production of a firm is constrained by both its number of permits and their associated MTBs. Production at a site may be constrained by the environmental carrying capacity of the site. When production per permit is constrained by the MTB, which according to industry sources

[14] We will not go into this any further, but information can be found on https://www.fiskeridir.no/Akvakultur/Tall-og-analyse/Loennsomhetsundersoekelse-for-laks-og-regnbueoerret/Matfiskproduksjon-laks-og-regnbueoerret
[15] Again see https://www.fiskeridir.no/Akvakultur/Tall-og-analyse/Loennsomhetsundersoekelse-for-laks-og-regnbueoerret/Matfiskproduksjon-laks-og-regnbueoerret

generally is the case, in economic terminology a *shadow value or price* will be associated with this constraint. This shadow value represents the increase in net profits if the MTB were to be increased by one unit.

It is important to recognise, however, that the various regulations operate jointly. Thus, a permit will come with an MTB. In principle, production can expand by increasing the MTB per permit, and much of the increase in production capacity as part of the "traffic light" system may be in the form of increased MTBs. Nevertheless, irrespective of whether the available permits or the MTBs or the multiple of the two is what is binding, the constraint(s) generally gives rise to economic rents which, since they stem from regulatory constraints, may be described as regulatory rents.

4. ECONOMIC RENTS: THEORETICAL ESSENTIALS

In NOU 2019:18 and some its key sources (e.g. Greaker and Lindholt 2019; Flaaten and Pham 2019), certain net economic outcomes of are referred to as "rents" or "natural resource rents". By employing this terminology, affinity, even conformity with the theoretical concept of economic rents is suggested. However, in NOU 2019:18 the term "grunnrente" appears to be virtually synonymous with profits. The same applies to what Flaaten and Pham (2019), a major source for NOU 2019:18, refer to as "resource rent in aquaculture". Apart from making no sense to introduce a new word for profits, this use of the term "rent" is not in accordance with the concept of economic rents as defined in economic theory.[16]

4.1 Economic rents: The theoretical concept

The concept of economic rents has a long history in economic theory. It played an important role in physiocratic thinking including the writings of Quesney in the 18th Century and, subsequently, the classical economics founded by Adam Smith. In both physiocratic and classical economics economic rents represented the price at which some asset could be rented out. Smith in his value theory regarded rents as an occasional component of profits (see Smith 1776). Ricardo (1817) further developed the concept and applied it in his theory of diminishing returns to agriculture. Hence the well-known concept of land rents. Later classical economists including J.S. Mill and Marx employed the concept in similar ways (see e.g. Samuels et al., 2003).

The concept of economic rents was reviewed by Armen Alchian in the New Palgrave Dictionary of Economics (1987).[17] According to him, economic rents are:

"..the payment (imputed or otherwise) to a factor in fixed supply".

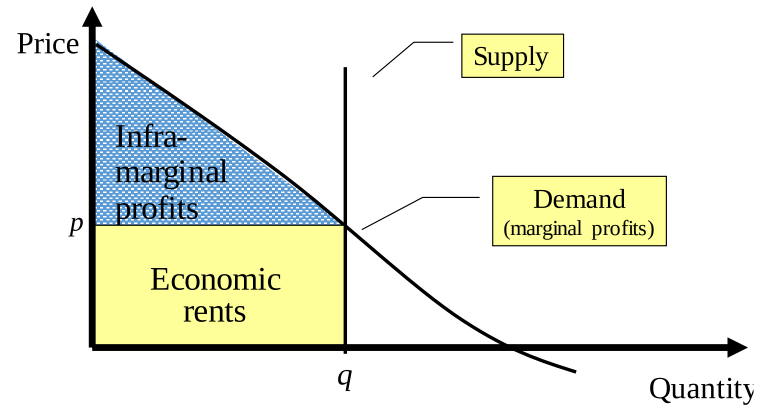
Alchian illustrates his definition with the diagram in figure 4.1. In this diagram, there is a demand curve and a supply curve. The demand curve may be regarded as marginal profits (or, more generally, marginal benefits) of using the factor. The supply is fixed at quantity *q*. The market-clearing price is *p*. Since the quantity of the factor is assumed fixed, *q*, would be forthcoming even if

[16] There are other problems with how the term rents is employed and interpreted in some applied writings about natural resource use. These, however, will not be discussed in this section which is concerned with the theoretical essence of the concept.

[17] Essentially the same definition of the term was offered in the revised version of the same article in 2008.

the price were zero. Hence, the entire price, *p*, may be regarded as a surplus per unit of quantity. The total surplus attributable to the limited variable is the rectangle *p·q*. This amount is what Alchian and the classical economists define as economic rents. Indeed this is the maximum rent owners of the variable could charge the demanders for the quantity *q*.[18] Note, however, that even if there are no owners charging *p·q* in figure 4.1, this amount would still constitute the economic rents associated with the restricted variable, *q*. Hence the qualification "imputed or otherwise" in the above definition of economic rents.

Figure 4.1
Economic Rents



It is important to realise that the economic rents depicted in figure 4.1 do not represent the total profits obtained from the supply *q*. These are measured by the sum of economic rents and the infra-marginal profits represented by the upper triangle in the diagram.[19] Thus, if the producers have to pay the rent *p·q*, their net profits would be the infra-marginal profits while the rentier would gain the economic rent *p·q*. Total profits from the supply *q* would be the sum of economic rents and the infra-marginal profits. Thus, in this case, total profits would be greater than economic rents.

Figure 4.1 conveys the essence of the concept of economic rents. Note, however, there may be situations where the variable in question in not continuous but comes in discrete chunks. Moreover, these chunks may be heterogenous, i.e., of different productivity. This applies for instance to land of different quality and, of particular interest in the context of this study, sites for marine aquaculture. While the definition of economic rents is unchanged, to illustrate rents for such variables, figure 4.1 has to be accordingly modified (see section 4.4.2 below).

Note that as far as the above definition of economic rents is concerned it is immaterial why or how the supply is fixed. It may be fixed for many reasons. It may be fixed because of limited natural resource availability as Ricardo's land of quality. It may be fixed for public regulatory reasons such as geographical zoning restrictions or a limited number of production permits as is often the case in

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18 If the owners attempted to charge a higher rental price per unit than *p*, the demand would be reduced and they would not be able to rent out the entire quantity, *q*. If they charged a lower price the rent would be reduced and there would be excess demand in the market generating an upward pressure on the rental price.

19 Some authors refer to the infra-marginal profits in figure 1 as infra- (or intra-) marginal rents (see e.g. Coglan and Pascoe 1999 for fisheries and Blaug 2000 more generally).

aquaculture. It may be fixed for economic reasons e.g. by suppliers enjoying some monopolistic position in which case the resulting rents are sometimes referred to as monopoly rents (Varian 1984).

Obviously, the empirical relevance of variables in fixed supply may be questioned. After all it is in the nature of the economic activity to find ways to adjust supply to demand, particularly when profits can be made doing so. Even Ricardo's (1817) argument in terms of the "original and indestructible powers of the soil" does not ring true. Surely, modern technology has enabled us to both reduce and enhance these powers. Thus, it is not easy to find examples of variables that are truly in fixed supply, especially in the long run. Indeed, the most likely candidates for such variables seem to be natural resources which cannot be augmented. Unique natural geological phenomena seem to belong to that category. In the very short run, on the other hand, many variables are in fixed supply and, consequently capable of earning economic rents. To represent this phenomenon of transient or temporary economic rents, Marshall (according to Achian 1987) initiated the concept of quasi-rents.

If there are no fixed variables, the above definition of rents does not really apply. However, a moment's thought will reveal that what is crucial for the existence of rents is not fixed supply but that slightly weaker requirement that the marginal cost of supply be less than the demand price.[20] This observation motivates the following generalised definition of economic rents (see e.g. Robinson, 1938; Worcester, 1946 and Alchian, 2008):

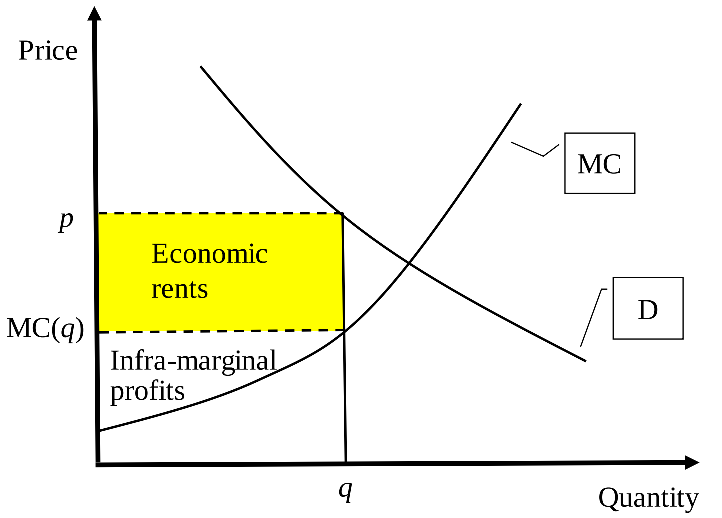
> "*Economic rents are payments (imputed or otherwise) to a variable above the marginal costs of supplying that variable*".

Note that this definition includes Alchian's (1987) definition of rents, and hence Ricardo's land rents, as well as monopoly rents as special cases.

[20] Note that a fixed variable that is binding (i.e., actually restrictive) is sufficient for rents but not necessary. For instance, monopoly rents do not rely on a fixed variable.

This definition of rents may be illustrated by means of the familiar diagram in figure 4.2. In this diagram, the demand is represented by the curve D. The marginal cost of supply is represented by the curve MC. If demand is taken as exogenous and q is unrestricted, a profit maximising equilibrium is found at the intersection of the two curves where MC=D and there are no rents. However, if the quantity is restricted to q in the diagram, the demand price rises to p, well in excess of the MC at q, and there will be positive rents indicated by the rectangle $q\cdot(p\text{-MC}(q))$.

Figure 4.2
Economic Rents



Note that there is no essential difference between the depiction of economic rents in figures 4.1 and 4.2. They are just two different perspectives on the same phenomenon. The difference between D and MC at the quantity q in figure 4.2 is just marginal profits at q. Therefore D-MC is simply p-MC(q) which is of course marginal profits at q. Thus, the difference between the price p and the MC-curve in figure 4.2 corresponds exactly to the marginal profit curve depicted in figure 4.1. Moreover the area above the MC-curve in figure 4.2 but underneath the economic rents is exactly the infra-marginal profits depicted in figure 4.1.

Adopting the above generalised definition of rents, denote the quantity of the variable by q. Write the profit function as $\Pi(q,\boldsymbol{z})$, where the vector $\boldsymbol{z}$ denotes all the other variables profits depend on such as technology, capital, entrepreneurship, natural resources stocks, expectations, prices and more. Then, as further explained in appendix A, a formal expression for economic rents is:

(1) $$R(q,\boldsymbol{z}) = \Pi_q(q,\boldsymbol{z})\cdot q,$$

where $\Pi_q(q,\boldsymbol{z})$ denotes the marginal profits of the variable q. For precision of terminology, it is useful to refer to the rents expressed in equation (1) as "rents associated with the variable q". Note that if q in the expression of rents above is not binding (although it may be fixed), profit maximisation implies that $\Pi_q(q,\boldsymbol{z})=0$ and the rents will be zero. In this way some upper bound (restriction) on the variable q is seen to be necessary for the existence of positive rents.

4.2. Properties of economic rents

Economic rents have some properties which are of considerable practical relevance. In this section we discuss two of them.

4.2.1 Rents and profits

From the definition of economic rents it is obvious that they are conceptionally different from profits. In fact, there is no particular quantitative relationship between rents and total profits – either can be larger or smaller than the other. This is formally shown in appendix B. As explained in appendix B whether rents are larger, smaller or equal to profits depends on the shape of the profit function and the size of fixed costs. These basic findings are summarised in table 4.1.

Table 4.1. Relationship between profits and rents

	Shape of profit function	
Fixed costs	Linear, $\Pi_{qq} = 0$	Strictly concave, $\Pi_{qq} < 0$
Positive ($\Pi(0) < 0$)	Rents>profits	?
Zero ($\Pi(0) = 0$)	Rents=profits	Rents<profits

Thus we see that economic rents can be either greater or smaller than profits. In particular, in the most plausible situation, i.e., a strictly concave profit function and positive fixed costs, the relationship is indeterminate (indicated by "?" in table 4.1.

The relationship between variable profits, i.e., $\Pi(q) - \Pi(0)$, and rents is much more straight-forward. As shown in appendix B, variable profits are always greater than or equal to rents provided the profit function is at least weakly concave. In fact, as illustrated in figures 4.1 and 4.2, in that case, the sum of infra-marginal profits and rents equals variable profits.

Needless to say, since there is no particular quantitative relationship between economic rents and profits, rents cannot be estimated by some variant of profits.

4.2.2 Rents depend on all the variables in the profit function

As made clear by equation (1), economic rents depend on all the variables in the profit function. It immediately follows that it is not logically possible to attribute the rents to any single one of these variables. All of them have an impact on the value of the function. The restricted variable (with respect to which the profit function is differentiated in equation (1) to calculate rents) does not play a special role in this respect. A restricted variable is of course necessary for positive rents. However, the same applies to all the other variables in the profit function.[21] They are also necessary to generate the rents. If some of these other variables are reduced, marginal profits will be less[22], the demand (marginal profit) curve in figure 4.1 shifts toward the origin and the rents associated with *q* are reduced. If some of these other variables, say output price or technology, are sufficiently reduced the marginal profit curve will intersect the horizontal axis before *q* is reached so that it ceases to be binding and there will be no rents (see figure 1).

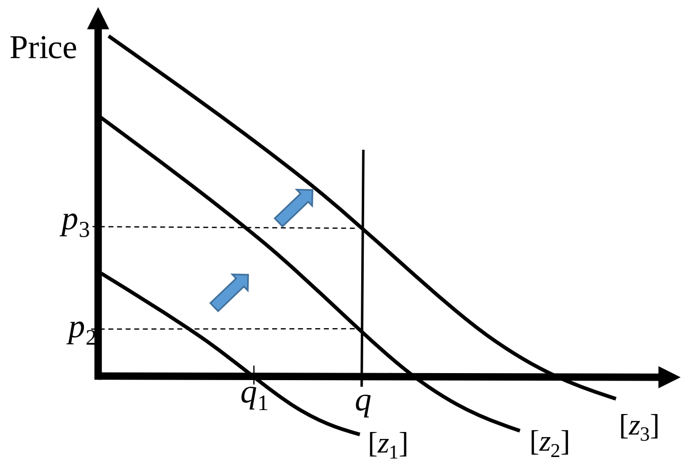
It is of course true that rents are something a producer with access to the appropriate technology would be willing to pay for *q*. However, the same applies to all other currently restricted variables in the profit function such as capital, technology, regulations, prices and so on. The producer would also be willing to pay rent for these variables. Thus, all the variables in the profit function[6] can be said to generate rents. Therefore, it is totally arbitrary to single out one of these variables, such as natural resource use, as the only one generating rents, let alone the profits.

As an example, consider a natural resource capable of yielding *q* on a sustainable basis. Assume that initially there is such a low demand for the yield that *q* is not binding and, therefore, there are no rents. Now assume that the user of the resource engages in a marketing effort (e.g. by providing information to the public) so that demand shifts sufficiently for *q* to become binding. Thus, marginal profits at *q* are positive and rents arise. Now the question is whether these rents are attributable to the resource or to the marketing effort. The answer of course is that the rents stem from the combination of both. Both are necessary and neither sufficient. To attribute the rents to one and not the other is just a senseless as to attribute profits (output) to one input variable and not the others.

[21] Recall that the profit function is a function of variables that cannot be maximised out and are in that sense restricted.
[22] Assuming a higher level would increase profits.

This essence of this example is illustrated in figure 4.3. The graph in this figure corresponds to the rents illustration in figure 4.1. The restricted variable is q. Initially the other variables in the rent function are not very favourable for profits namely at z_1 so that marginal profits are comparatively low. Therefore, q is not binding. Marginal profits at the profit maximising point q_1 are zero and there are no rents. All the profits are infra-marginal ones. Subsequently, z becomes more favourable at z_2. This could for instance be because of investments undertaken by firms in the industry. The constraint q becomes binding and there will be positive rents equal to $p_2 \cdot q$. Notice that as the figure is drawn, there will also be substantial infra-marginal profits. If the other factors increase further to z_3, rents increase further to $p_3 \cdot q$ and the infra-marginal rents may increase or fall.

Figure 4.3
How other variables generate rents



Now the question is whether the increasing rents illustrated in figure 4.3 (which in our terminology are associated with q which might be a natural resource) are more reasonably attributed to q or to the other inputs z. Since q does not change while z does, many would think it more reasonable to attribute the rents to z rather than q.

Much the same applies to infra-marginal profits. They also depend on all the variables of the profit function as well as the possibly restricted variables such as q in diagram 4.3. Therefore, it is just as pointless to attempt to attribute observed infra-marginal rents to a particular variable in the profit function such as e.g. company efficiency.

The fundamental point is that there are generally many variables (constrained and unconstrained) that generate values for the objective function. The claim that one or a subset of them is solely responsible for the profits is at best misleading. To see this, just set one of the necessary variables, e.g. labour, equal to zero and see what happens to the rents.

4.3 Economic rents: More complicated cases

The basic theory of economic rents expressed in chapter 4.1 may be extended to more complicated cases in a straight-forward manner.

4.3.1 More than one restricted variable

At any given time, the profit function generally depends on a number of variables.[23] A particular natural resource such as fish stock or an aquaculture site is just one of these variables. Other variables in the profit function typically include technology and know-how, physical and human capital, marketing channels, contracts etc. and, of course, input and output prices. All of these variables can give rise to rents in exactly the same way as natural resources. For instance, the firm's technology is usually very valuable and the firm would dearly like to have more (a better) technology. This means that the firm would be willing to pay a rent for this technology if necessary. In fact, there are many instances of firms actually paying such rent (e.g. license fees).

To express this more formally, let $\Pi(\boldsymbol{q})$ be the profit function with the vector *q* representing all the variables affecting profits. Then, according to the basic definition of economic rents in equation (1), rents from each of the independent variables in the profit function are:

$R(\boldsymbol{q};i) = \Pi_{q(i)}(\boldsymbol{q}) \cdot q(i)$, all *i*,

where the index *i* refers to variable *i*.

Total rents from all of the variables in the profit function are:

$$(2) \qquad TR(\boldsymbol{q}) = \sum_{i=1}^{I} R(\boldsymbol{q};i),$$

where *TR*(*q*) denotes the total rents, *R*(*q;i*) the rent from variable *q*(*i*) and *I* is the total number of variables. Needless to say, since individual rents may be larger or greater than profits, the same applies even more so to total rents.

The above suggests a couple of immediate inferences:

- Since each operation generally defines a number of rents, to focus on just one of these is arbitrary and potentially seriously misleading.
- Measuring just one type of rent out of several runs the risk of substantially overestimating this rent.

4.3.2 Discrete, heterogeneous subsets of the same variable

Some economic variables consist of discrete subsets (or segments) that are not equally productive, i.e., they are heterogeneous with respect to profits. This applies for instance to many natural resources

[23] By the nature of the profit functions, all these variables are restricted (at least at the time). Some of the restrictions may, however, not be binding.

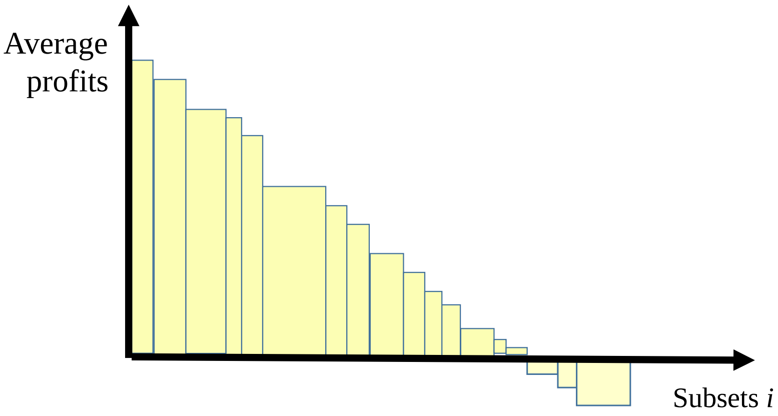
such as plots of land and sites for fish farming. This heterogeneity will generally result in differential marginal products and, therefore, also different rents if they exist.

Formally, we may represent the collection of these heterogeneous variables by the set Q defined by:

$Q=\{q(i);\ i=1,2,\ldots..\}$,

where each $q(i)$ represents a subset of equally productive homogeneous variables generating the profit function $\Pi(q(i),z;i)$, where, as before, the vector z represents all other variables and the index i in the profit function indicates that there are different profit functions for each subset of the variable.

Figure 4.4
Profits from heterogeneous segments of the variable



Arranging these heterogeneous subsets of Q in an order of declining average profitability gives rise to a diagram such as in figure 4.4. In this diagram, the columns indicate different homogeneous subsets of the variable Q. The width of the columns represents the quantity of that homogeneous subset. Note that the quantity within each subset is different which of course would normally be the case. The height of each column represents the average profits obtainable from that subset of Q and the area measures the (variable) profits from the subset.

The situation depicted in figure 4.4 may describe profits from different types of land, the basis for Ricardo's theory of land rents, or profits from different sites for fish farming and so on. It may even describe the profits from identical subsets of Q, for instance identical fish farming subject to different regulatory regimes.

Instead of regarding Q as one variable consisting of heterogeneous subsets, it is more natural as well as convenient to regard each homogeneous subset of Q as a separate variable. In that case, we are essentially back in the basic analytical framework for economic rents outlined in section 4.1 and illustrated in figure 4.1. Each homogeneous subset of Q will, provided its marginal profits are sufficiently high, generate economic rents defined by: [24]

[24] Note that although the $q(i)$s may only be available in discrete segments as depicted in figure 4.4, the marginal profits (derived from the profit function of the producer) would still be defined.

(3) $$R(q(i),\boldsymbol{z}) = \Pi_{q(i)}(q(i),\boldsymbol{z}) \cdot q(i) \, ,$$

where the $q(i)$s represent the restricted quantity of each homogenous subset of Q. Importantly, if the profit function is concave, there will also be infra-marginal rents and the economic rents will be less than the average variable profits depicted in figure 4.4.[25] How much less, however, depends on the size of the $q(i)$ and the concavity of the profit function as indicated by figure 1.

The different subsets of Q give rise to different rents, infra-marginal profits and, of course, variable profits.

It may be noted that since each discrete homogeneous segment of Q, $q(i)$, say, is a unique commodity, it is highly likely that it belongs to one owner. This owner then is fundamentally monopolist. His market position is similar to that of the owner of a unique piece of art or, for that matter, a plot of land or a aquatic site for fish farming. Therefore, he may be in a position to extract a substantial part of the infra-marginal profits obtainable from using of $q(i)$. It is important to realize, however, that this would reflect a monopoly surplus and not amount to a higher economic rent. The true economic rent is still defined by equation (1) and its counterpart for discrete, heterogeneous subsets (3).

[25] See table 4.1 and appendix B.

5. RENTS IN NORWEGIAN SALMON AQUACULTURE

As discussed in chapter 3, production in Norwegian salmon aquaculture is primarily constrained by (i) permits to produce, (ii) maximum allowable standing biomass or MTB per permit and (iii) allowable sites for production. Since the MTB is closely related to the maximum amount of production, it will often be referred to as a production constraint in what follows[26].

Taken together, these three constraints give rise to a somewhat complicated regulatory environment. It is made more complicated by the fact that while some constraints may be binding for certain companies and certain locations, they may not be binding for all firms and locations.

Rents typically emerge when some variable of the profit function is constrained. Thus, each of these three restrictions on salmon aquaculture in Norway may give rise to economic rents. Unfortunately, since production can only occur when all three regulatory requirements are met, it is empirically difficult to separate out the rents associated with each one of them.

5.1 Site rents (rents associated with sites)

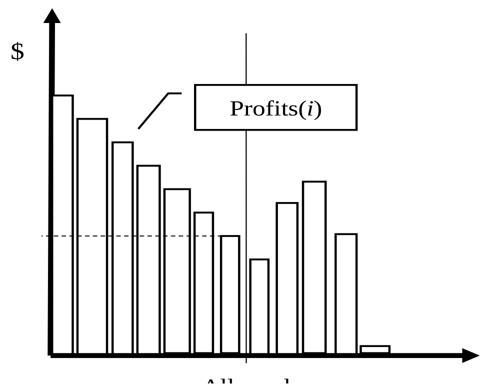
Salmon aquaculture is conducted at geographically distinct sites. These sites are not of the same quality with respect to salmon culture. They vary with respect to ocean currents, water renewal rates and temperatures, shelter from waves and wind, available labour supply, transporation and so on. It follows that the attainable profits and, therefore, also economic rents, differ across these sites. Thus, as regards profits and rents, sites for salmon aquaculture comes under the framework of discrete heterogeneous units discussed in section 4.3.2 above. Each site offers a particular combination of natural and other attributes. Thus, each site defines a particular productive resource. In this way, aquaculture sites correspond to plots of productive land in the classical economic theory of land rents.

[26] The actual production naturally tends to exceed the MTB as it is essentially the growth of the biomass that is harvested and biomass in excess of the MTB must be harvested so as not to exceed the constraint..

Figure 5.1 illustrates the profits associated with different sites (assuming permits for a certain production quantity are in hand). As already mentioned, the sites consist of discrete units of different quality and, therefore, different profitability. It is assumed in figure 5.1 that the allocation of sites is restrictive, i.e., not all profitable sites are allocated. In the diagram, the allocated sites are arranged in order of declining profitability. The non-allocated sites may be more or less profitable than the allocated ones, as illustrated in the diagram. The width of the bars may represent the production constraint of the site in the form of a permit or site MTB.

Figure 5.1

Site profits



Obviously, each site can be rented out for a price up to its (expected) profits.[27] This may give rise to differential site rents where the highest site rents are for the most profitable sites. The minimum site rents are those associated with the least profitable site allowed.

The profits associated with a given site should not be attributed to the site and labelled site rents without further investigation. First, as discussed at length in section 4.2.2 above, the profits obtained at a given site depend on all the variables affecting the profit function and not just the attributes of the site. Without these other variables, there would be no profits from aquaculture at this site. Second, a subset of the variables affecting the profits at the site is under the control of the firm conducting the aquaculture operation. To the extent that these variables are specific to the firm, they may generate infra-marginal profits in the sense discussed in section 4.1. Salmon aquaculture is a complicated, highly technical business which has been in the process of great expansion. For these reasons, one might expect wide efficiency differentials between firms. Indeed, there is empirical evidence (Asche and Sikveland 2015; Dahl and Idsø 2017) that there is a great difference between the efficiency of the firms. The most efficient operator at each site will only have to pay rents equal to the profits obtainable by the next most efficient operator. It follows that the infra-marginal profits associated with each site might be a high fraction of the total profits. Third, economic profit is the economic return above the alternative. If the companies have access to alternative sites for aquaculture outside of Norway generating certain net profits, these profits represent the opportunity

[27] As discussed in section 4.3.2, since each site is unique, the actual rent that may be extracted from its use may exceed the true economic rents.

cost of choosing to produce in Norway. Therefore, the maximum rent they would be willing to pay for sites in Norway is only the additional profits these sites can offer. Thus, in this case the true economic rents as well as the actual rent that can be collected could be much less (possibly even a small fraction) of the profits obtainable from a site in Norway.

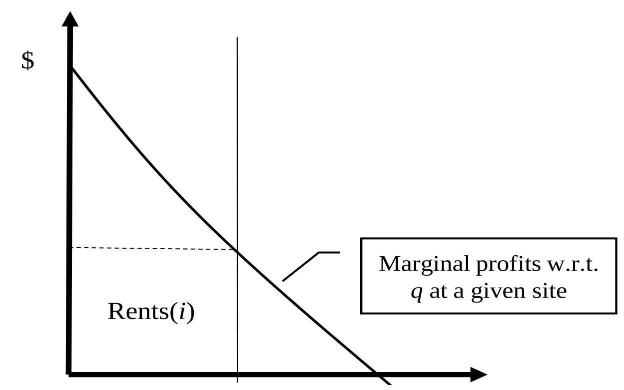
5.2 Production rents (rents associated with the level of production)

Obviously, the profits and marginal profits from each site depend on the production level as well as many other variables. As discussed in section 4.3.1, each of these variables may give rise to rents. Indeed, if they are subject to binding restrictions, they will. In section 4.2.2 above it is explained that these rents cannot in general be traced only to one constrained variable. The rents associated with one variable will in general depend on all the variables in the profit function.

The production or, for that matter, the MTB associated with a permit gives rise to the standard rent diagram as illustrated in figure 5.2. If the quantity stipulated in the permit being used at this site is binding, there will be positive rents as illustrated in the diagram and normally (possibly substantial) infra-marginal profits. If there is only one company operating at the site, these infra-marginal profits would primarily be due to diminishing marginal profits in its operation. Note that production rents would normally vary from site to site depending both on the site and company efficiency. Thus, there might be production rents at some sites, even if the overall production limits (calculated as no. of permits times their average MTB) might exceed total production.

Figure 5.2

Production profits (at a given site *i*)



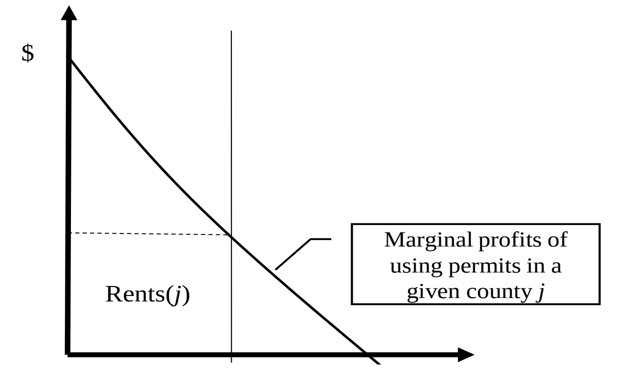
5.3 Permit rents (rents associated with permits)

If the issue of permits is restrictive, there will also be permit rents. Permits are normally issued for a given production area. With the permit in hand, the permit-holder will have to search for good production sites. Thus, within the production area, the permits may appear to constitute more of a homogeneous factor than between areas. We will assume this is the case. Therefore, although the permits come in integer numbers, the possible rents associated with them may be illustrated with a standard rent diagram similar to figure 5.2.

In figure 5.3, the downward sloping curve represents the marginal profits in the industry from using permits in a given production area. This of course is also the demand curve for permits. In the figure, the number of permits issued in some production area *j* is assumed to be restrictive. Therefore, as illustrated, rents associated with the permits emerge. There are probably also significant infra-marginal profits. These are primarily due to differences in company efficiency but may also represent diminishing marginal profits within each company.

Figure 5.3

Permit profits (for a given production area)



5.4 Total rents in Norwegian salmon aquaculture

It is important to realise that any rents that might be measured at a given aquaculture site are likely to be a combination of production rents, permit rents and site rents. Therefore, although analytically distinct, it is exceedingly difficult, maybe impossible, to disentangle the share of each of these three types of rents in the total rents at the site.

Production rents and permit rents and to a lesser extent site rents are the consequence of man-made restrictions. Therefore, even in the case where these man-made restrictions reflect real natural constraints, it is misleading to refer to them as natural resource rents. Natural limitations are neither necessary nor sufficient for these rents. The regulations, on the other hand, are necessary for their emergence. Therefore, these rents are more reasonably referred to as regulatory rents.

Moreover, as repeatedly explained above, any observed rents depend on all the other variables affecting the profit function most of which have nothing to do with the natural resources at the farm site. This makes it even less reasonable to attribute observed profits or rents in aquaculture to these natural resources.

5.5 Summary

- The profits observed in Norwegian salmon aquaculture stem from many variables. The natural resources used in the production, mainly those present at the farm site, are only a subset of these variables. It follows that these profits, as well as the possibly associated rents, cannot be attributed solely to the natural resources.

- A part of the observed profits is not rents but infra-marginal profits stemming primarily from the different efficiency of the companies and diminishing marginal productivity at each site. In practice, it is difficult to disentangle these infra-marginal profits from the rents.
- If the Norwegian salmon aquaculture industry has access to production sites outside of Norway, their opportunity (i.e., real economic) profits from using Norwegian sites is only the additional profitability of these sites. It follows that the price (or rent) that could actually be collected for using the Norwegian sites cannot be greater than the profit differential, even if the accounting profits (measured on the tacit assumption that alternative opportunities yield zero profits) are much higher.[28]
- Since regulatory restrictions (limited permits and production levels) may be responsible for a good part of the observed rents in Norwegian salmon aquaculture, this part of the rents is properly referred to as regulatory rents.

[28] This has important implications for the distortionary impact of rental taxation of the aquaculture industry.

6. IS RENT TAXATION ECONOMICALLY NON-DISTORTIVE?

A common argument for taxation of economic rents associated with natural resource use is that such taxation is non-distortive, i.e., it does not have an impact on production or the use of economic factors and is therefore economically neutral (see e.g. Garnault and Clunies-Ross 1979, Fraser 1995, Grafton 1995 and Miller et al. 2000). In NOU 2019:18 it is repeatedly asserted that correctly designed taxation of "grunnrente" will have this property. The main argument given seems to be that salmon aquaculture in Norway is based on favourable ocean sites that being geographically fixed natural resources cannot respond to taxation. For instance, in the introduction (chapter 1.2.2. p. 5) it is claimed that:

> "En riktig utformet skatt på grunnrente som knytter seg til stedbundne ressurser, vil for eksempel virke nøytralt."

This belief seems to be the main reason for the committee's recommendation that this "grunnrente" in salmon aquaculture be subject to special taxation.

While the taxation of "grunnrente" proposed in the report is not a tax on economic rents – it is actually more similar to an extra profit income tax - it is important to recognise that tax on economic rents is in general economically distortive (see e.g. Johnston 1995, Grafton 1996 and Arnason 2002). This basic finding is formally demonstrated in appendix C. The main reason for this result is that, although the constrained variable cannot be altered in response to the taxation (as long as the constraint remains binding), it is generally combined with a set of other variables that can be altered by the companies in order to maximise profits. Indeed, as shown in appendix C, if a company is subject to rent taxation it will generally find it to its advantage to adjust its use of these other inputs. Thus, the argument made in NOU 2019:18 that because the aquaculture sites in Norway constitute a natural resource that cannot be moved, taxation of aquaculture is non-distortive, misses the mark. Many of the other variables used in aquaculture can be altered and, in general, their use is sensitive to rent taxation.[29]

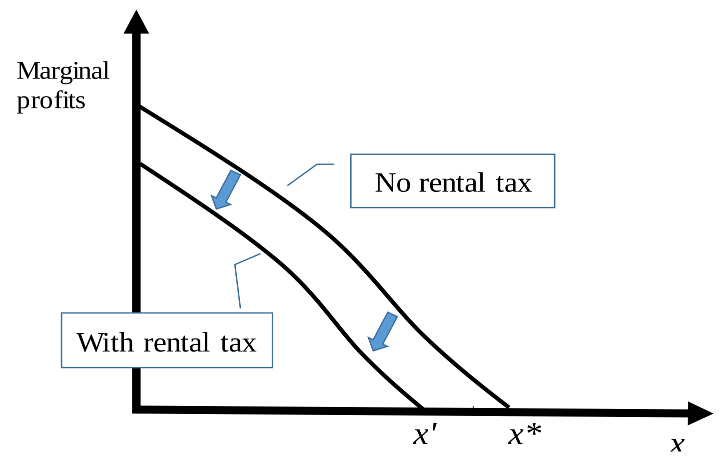
The impact of rent taxation on the use of the controllable inputs may be illustrated as in figure 6.1. The figure depicts the marginal profit curves for a controllable input, x, say. The upper curve is

[29] Although within the scope of this report it is not possible to show that much the same holds for other forms of taxation, including income taxation, we believe that to be the case.

drawn assuming no rental tax. For this curve, the profit maximising level of *x* (occurring when the marginal profits are zero), is *x**. With the rental tax imposed the marginal profits of using *x* is reduced[30] with the result that the profit maximizing use of *x* falls to *x*´. This simple argument shows that tax on rents is in general economically distortive. A more formal argument presented in appendix C yields the same result.

Figure 6.1

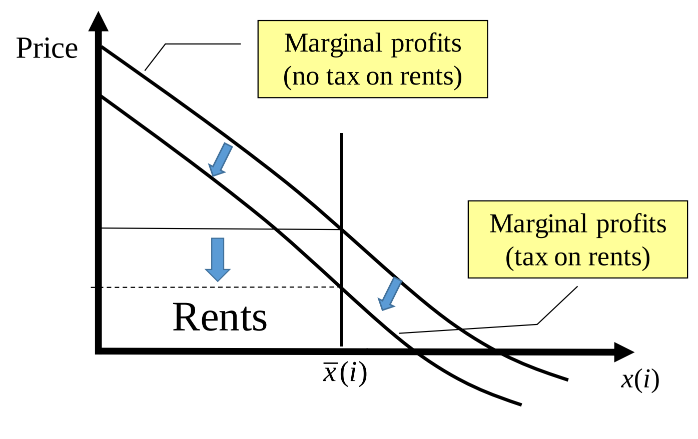
Impact of rent taxation on use of controllable input



The basic economic reason for adjusting input use in response to rental taxation is to maximise retained profits, i.e., profits after the tax, given this new rental tax. In the short run, this can only be accomplished by reducing the subject of the tax, namely the rents. Therefore, the companies will adjust input use until the resulting losses in profits equal the gains from less rental taxation. As shown in appendix C, this normally implies less input use and, therefore, less profits before tax. For the rental tax to have no impact on input use requires extreme assumptions that are unlikely to apply in the real world. Most or all of the controllable inputs would be reduced. Among them would be use of feed and similar daily inputs, as well as the investments in technology and equipment and the use of capital.

Figure 6.2

The impact of rent taxation on profits and rents



Less use of productive inputs implies that marginal profits from resource use fall. Therefore, as illustrated in figure 6.2, both the profits and economic rents from the operation are reduced. Infra-marginal profits, however, may either rise or fall.

[30] This is on the highly likely assumption that *x* has a positive impact on the marginal profits of the constrained variable.

Taxation of economic rents in aquaculture can have several impacts on the operation in addition to the flow use of inputs. These potential impacts include:

- The timing of production phases and rotational arrangement of the aquaculture operation.
  With altered profitability, it is generally optimal to change the aquaculture rotational cycle.
- Investment and industry entry and exit decisions.
  Taxation reduced the expected profits of investments. It also discourages entry into the business and encourages exit.
- The risk structure of the aquaculture operation.
  With reduced retained profits, the risk of financial difficulties and bankruptcy in the operation is increased.
- The cost of capital to the aquaculture companies.
  With reduced retained profits, the risk of providers of capital is increased. Therefore, they demand a higher expected rate of return on their capital. Moreover, there may be less retained profits to strengthen the solidity of companies and fund investments.
    - The capitalised values of production permits will be reduced. Essentially this implies a government fiat to confiscate part of companies' assets.
    - The tax will reduce the competitiveness of the Norwegian industry vis-à-vis producers in other countries. Moreover, it will reduce the competitiveness of Norwegian seabased aquaculture vis-à-vis alternative technologies.

How great these potential impacts are is a matter of empirical investigation. The numerical example presented in appendix C suggests the impact can be very substantial. Moreover, it should be kept in mind that there can be a great difference between the short run and the long run impact.

7. EVALUTATION OF SUPPORTING MATERIAL

As mentioned in section 1, the NOU refers to reports by Greaker and Lindholt (2019) and Flåten and Pham (2019) which allegedly present estimates of "resource rent". In this chapter we offer our evaluation of these two reports.

7.1 Report by Greaker and Lindholt

On behalf of the NOU Commission, Greaker and Lindholt (2019) have undertaken an empirical study of rent in the Norwegian aquaculture industry for the period 1984-2019. We will first summarise their analysis and then evaluate their methodology and results.

According to the authors, revenues from natural resources are related to the concept of resource rent or rent («grunnrente»)[31], two terms they use interchangably. Rent is defined as "...the income for the use of a natural resource that remains after all necessary factors of production have been paid their market based remuneration"[32] (our translation). We will return to their use of these concepts below.

Based on Eurostat (2020), the authors define resource rent as

i) Base value
+ ii) Product specific taxes
- iii) Product specific subsidies
- v) Wage costs
- vi) Normal return on capital invested
- vii) Depreciation
- iix) Non-industry specific taxes deducted non-industry specific subsidies.

Quantitative estimates are based on data from the national accounts of Statistics Norway. The production value (the "base value") includes both sales revenue and the value of the change in the stock of standing fish. The definition of aquaculture in the national accounts includes salmon, trout, cod, other farming and miscellaneous other activities. Ideally one would like to consider salmon and trout aquaculture only, however, the data do not make that possible. From a practical point of view, this is not likely to make much difference as salmon and trout dominate total production.

Regarding vi) normal return on capital invested, an opportunity cost of capital of 4% is used. As for the definition of capital, only tangible capital is included. As noted in section 3, permit values

[31] The authors use the terms "ressursrente" and "grunnrente" interchanbably.
[32] In Norwegian: «Grunnrenten er den inntekten fra å utnytte en naturressurs som blir igjen etter at alle nødvendige innsatsfaktorer har fått sin markedsmessige avlønning».

in aquaculture are very high. This kind of capital is not included in the authors' definition of capital, nor is the value of the firms' stock of fish, which also takes on fairly substantial amounts.

Figure 1 illustrates their estimateded "rent" for aquaculture for the period 1984-2014. All values are expressed in 2018-NOK. As noted, the opportunity cost of capital is set at 4%. The figure gives production value, estimated wage compensation, capital costs and "resource rent".

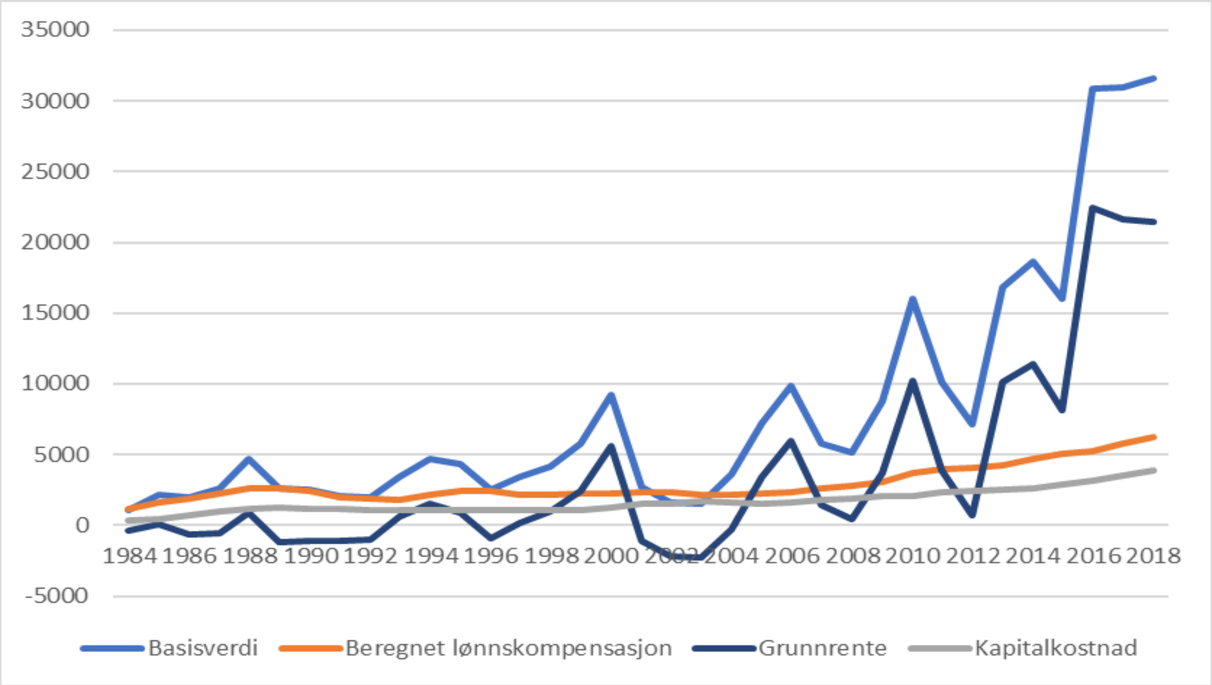


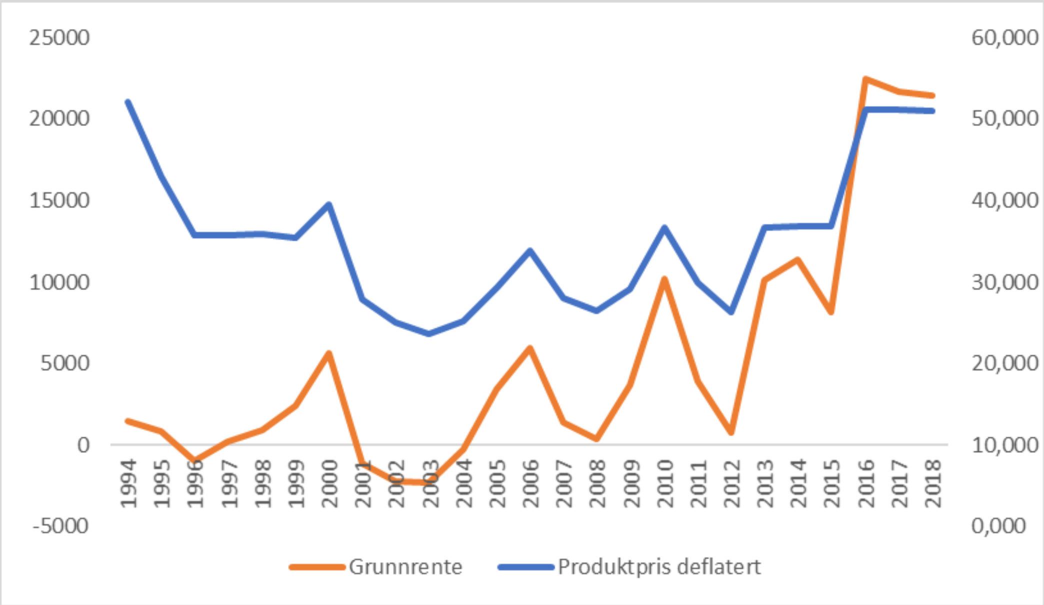
Figure 1. "Rent"in Aquaculture 1984-2018. Mill 2018-NOK.

According to these estimates, "rent" is highly variable over time. Up to the early 2000s the "rent" varied around zero and was even negative for some years; based on visual inspection of the diagram, average annual "rent" for the first 20 years of this time period was probably close to zero. After 2012 the "rent" increased considerably and exceeded NOK 20 billion for the past three years. This high variability in their estimated "rent" immediately suggests that this this alleged "rent"cannot be "resource rent" in the sense of being generated by the natural resource (i.e., the aquaculture sites). Surely the quality of the natural resouce, namely that of the aquaculture sites, was largely constant during the period in question or at least did not vary this much. Therefore, something else must be responsible for the fluctuations and subsequent upward trend in their estimated "rents".

Increased salmon and trout prices since 2012 appear to be the main explanation for the fluctuations in their estimate of aquaculture "rent" as suggested by figure 2 which shows average real price of salmon[33] and "rent" per year. The increasing trend in the "rent" from 2013, however, is only

[33] The report does not state what is the base year for the price series.

partially explained by the price – price was also high in 1994-5 when the estimated "rent" was low. The difference is most likely attributable to advances in technology and improved marketing channels.



Figre 2. «Resource Rent» (Mill 2018-NOK) and Salmon Price Real NOK/kg.

Greaker and Lindholt have worked out a number of sensitivity analyses including the impact of changes in wage costs and the opportunity cost of capital on their estimates. Although varying these varaibles has a significant impact on estimated rent, the qualitative nature of their results is unchanged. According to the authors, a "robust" conclusion of their work is that there has been "substantial resource rent" in aquaculture since year 2000[34].

Evaluation

The Greaker and Lindholt (2019) report has very serious limitations in terms of methodology. As described in secion 4 of this report, there is an important disctinction between economic rent and inframarginal profits. While economic rent will be the same for all units, inframarginal profits will vary from firm to firm. The difference between resource rent and inframarginal profits is not even mentioned by Greaker and Lindholt (2019).

In this report, we have argued that inframarginal profits are likely to be relatively large in this industry, for reasons such as as differences in company efficiency, employed technology, efficient

[34] The conclusion that there has been "substantial resource rent" in aquaculture since year 2000 is a bit curious as figure 1 shows negative values for 2001-03, zero for 2004 and very low values for 2008 and 2012.

use of feed skill sets of employees, managerial capability and, of course, diminishing returns. Variations in the enviromental productivity of farm sites will also give rise to inframarginal profits between farms. Neglecting these infra-marginal effects implies that, from the point of view of economic theory, the methodology applied by Greaker and Lindholt is seriously flawed.

Another crucial issue ignored by Greaker and Lindholt is what factor constrains production in this industry. As we have argued in section 3, it is primarily the MTB and the number of permits issued by the government that effectively regulates production. This means that if there is true economic rent in this industry, it will be regulatory rent, rather some kind of resource rent.

In the very first paragraph of their article, Greaker and Lindholt define “grunnrente” as profit in excess of normal return on capital (supernormal profits or merprofit). Then they attempt to relate this "profit-grunnrente" concept to the use of natural resource inputs in various somewhat oblique ways, e.g. “..merintekt av å disponere en naturresurs...” [para 1] and “..grunnrenten fra naturresursser...” [para 2]. The intended implication seems to be that the natural resource somehow generates what they call "profit-grunnrente". The authors provide no analysis, no evidence or references to support this alleged relationship except for Eurostat (2002) which essentially presents an accounting relationship.

As described in section 4 of this report, there is a range of variables that generates the "profit-grunnrente. Moreover, many variables, including labour, capital, knowledge, management skills and more, are necessary for any "profit-grunnrente to be created. As explained in section 4, it is in general, neither analytically nor empirically, possible to attribute the operating result of companies to any one or a few of the inputs in the production process as it is the combination of inputs and other factors that produces the outcome. All one can say is that each of these factors may have a marginal value (shadow value). However, this marginal value multiplied by the amount used (i.e., the rent) is a far from measuring the total contribution of the factor to profits. Moreover, each marginal value depends on the other factors. Thus, this aspect of their report has no rational or scientific basis.

The authors then attempt to measure the "profit-grunnrente" by use of the national accounts. Importantly, in taking this approach, they miss the role of intangible inputs such as the entrepreneurship, network, connections, cleverness and management which are generally crucial for the profits of companies. These factors, although crucial, generally do not feature in standard profits and loss accounts or are severly undervalued in them if it features at all.

An implicit assumption in the idea to tax the "profit-grunnrente" is that the measured "profit-grunnrente" represents an equilibrium value. This ignores the fact that a high "profit-grunnrente" is often a temporary phenomenon in expanding industries due to new technology and other opportunities. If so, it is socially highly desirable to speed up the utilisation of these new opportunities. High profits signal to companies that they should do so. As a result, in the long run, the high profits disappear. This kind of situation is probably the case in salmon aquaculture.

In section 4 of this report, we explained the conceptual difference between rents and profits. Greaker and Lindholdt (2019), while purportedly estimating rent, are in fact estimating a type of profit. Finally, as noted above, the alternative cost of permits and the stock of fish is not included in their estimates. This implies that even their concept of profit is flawed.

In summary: Conclusions:

- «Grunnrente» as defined by Greaker and Lindholt (2019) is not economic rent. Economic rent is a totally different concept.
- Greaker and Lindholt (2019)| essentially measure a kind of profit. They do not in any way measure economic rent. Moreover, their estimate of profit is also flawed as they fail to include the opportunity costs of permits and the stock of fish not to mention various intagngible inputs discussed above.
- Geaker and Lindholt attribute profits solely to the natural resources used in aquaculture. Since the profits are gnerated by a long list of variables, this is totally untenable and, therefore, incorrect.

7.2 Article by Flåten and Pham

Flåten and Pham (2019) present estimates of "rent" in Norwegian salmon aquaculture and Vietnamese shrimp farming. While Greaker and Lindholt (2019) made use of the national accounts, Flåten and Pham use data from the annual cost and earnings studies of the Directorate of Fisheries which are based on aquaculture firms' annual accounts.

The authors define rents as profits which implies that they ignore inframarginal profits. Furthermore, they attribute their "rents" to resources only and, thus, implicitly assume that the other production factors (and variables) contribute nothing to the rents. Then they go on to talk about three different types of rents: (i) Ricardo, (ii) market and (iii) Faustmann rents where the last is really the aquaculture site value. This subdivision of rents is not analytically well developed and of no particular relevance. The authors then provide estimates of profits which they call rents in Norwegian aquaculture based on data for 2016. These estimates are subject to various objections even within the theoretical framework they have adopted[35].

[35] A small example – in table 1, total operating expenses (should be costs) include depreciation of farm, licence, and permit. It is not explained what difference there is between licence and permit, if any. Moreover, as noted in the NOU, there is no depreciation on licence as its lifespan is infinite.

As in the general case of economic rents discussed in section 4 above, rents or, for that matter, profits cannot be attributed to just one or few variables of the profit functions. It immediately follows, that to justify special taxation by the use of some natural resource in the production process, as is done in this report, is not logical. One can just as reasonably justify no taxation on the basis that the profits also depend on factors such as technology and entrepreneurial ability.

Interestingly, the authors acknowledge that profits (or rents) stem from a number of sources (p. 6, para. 3). They explicitly say that part of rents are caused by managerial skills/capital but to separate out the two requires micro data which they do not have and therefore they ignore them. In other words, they acknowledge other sources of rents but simply assume they are zero in their empirical measurements and discussion of rent. This implies that their measurement of resource rents by their own admission is erroneous or at best biased upward. The practical implication of this is that their estimate of rents (or profits) as a basis for public policy, as is done the NOU report, is at best inappropriate.

On p.5 of their report, the authors assert that in aquaculture there are three types of capital; (i) physical capital, (ii) fish, and (iii) site capital. This ignores among other things (iv) knowledge capital, (v) human capital, (vi) marketing capital and more. This is serious because of their wish to relate profits to natural resources.

As already noted, the article distinguishes between three types of rents; (i) so-called Faustmann rents (chapter 2.2), (ii) Ricardo rents (chapter 2.3) and (iii) what they refer to as market rents (chapter 2.4). It is asserted (p. 7) that in aquaculture, resource rent (total rent) is the sum of Ricardo rent and market rent.

Faustmann rent

The authors recount the standard derivation of the simple Faustmann rule (Bjørndal, 1988) and claim that the so-called site value (which is simply the present value of profits forever) is the natural resource capital of the farm, totally ignoring the multitude of factors combining to generate the profits as explained in detail above. Their concept of Faustmann rent is not really defined, but they seem to regard it as the annual return on the site value, i.e., $\delta \cdot V$, where V is the site value and δ the (company's) time discount rate.[36] It is important to realise that the site value V does not really have anything to do with the site. Any asset, e.g. a bond, that provides a constant periodic return will have the same formula for present value, i.e., the site value, although there is no site involved. To claim that the "site

[36] Defined in this way, the Faustmann rent is clearly a kind of average or equilibrium rent per annum.

value" stems from the site or natural resources more generally requires the additional (and implausible) argument that the profits stem only from the natural resource.

So, the Faustmann rent is simply the annual return on the present value of future profits generated by the Faustmann rule (and assuming constancy of all variables). It does not have much to do with natural resources.

Ricardo rent

The authors do not carefully define Ricardo rents. It seems, however, that they have the usual land rents in mind. The way they illustrate these rents in figure 2 (p.7), however, is somewhat peculiar. Essentially they claim that Ricardian rents are what is usually referred to as the total producer surplus (area G,H,C in their diagram in figure 2). It is worth noting that this is precisely the area underneath the marginal profit curve in the more standard representation of rents as presented in section 4 of the current report. This is peculiar because normally Ricardian rents, in accordance with empirical reality, assume that each discrete piece of land is rented for a given price. The way the authors define Ricardo rents leaves no room for infra-marginal profits in the use of each plot of land.

Where they get seriously off base, however, is when the supply of land is restricted (Q_R in their figure 2). In that case they claim that what they refer to as "market rents" (area AGFB in the diagram) emerge while Ricardo rents on used plots are unchanged. This is inconsistent with the definition of Ricardian rents in economic theory. If plots are restricted (which might be a natural constraint) and the output price rises (as they assume), Ricardian rents on used plots increase correspondingly. This, in fact, is a major component of the theory of Ricardian land rents and the falling rate of profits. So, if they authors want to stick to the standard theory of Ricardian rents, there is no "market rent". What the authors refer to as market rents is simply the increase in the Ricardian rents when available plots of land are reduced. Thus, the concept of "market rents" is totally unnecessary and only serves to confuse the basic issue.

Market rents

As discussed above what they call market rent is really only Ricardian rents at higher (than market equilibrium) output prices. This concept serves no useful purpose.

On p. 8, of the report, the relationship between the three types of rents they have identified is discussed. It seems that the authors intend the Faustmann rent to include both the market and Ricardian rent (at least in equilibrium) since Faustmann rent is the annual return on the site value (present value of profits). However, as we have seen, the market rents are just a part of the Ricardian rents. Thus, the rents they are really trying to measure, although they do not do it correctly, are simply Ricardian rents.

In summary:

- The rent concepts used by Flåten and Pham (2019) are not clearly developed. As far as we can see, the so-called Faustmann and market rents are redundant and the rents with which they are concerned are standard Ricardian rents.
- In their empirical work, Flåten and Pham (2019) essentially measure a variant of profit. They do not in any way measure economic rents.
- The authors ignore infra-marginal profits in their analysis. Since infra-marginal profits exist, this amounts to assuming them to be zero in their empirical work

7.3 Overall conclusions

The NOU uses the studies of Greaker and Lindholt (2019) and Flåten and Pham (2019) to "confirm" their beleif in the existence of "resource rent" in Norwegian aquaculture and, thus, to justify the introduction of "resource rent taxes". However, as we have explained above, these two studies do not produce any evidence of resource rents in Norwegian aquaculture and even less so, measure such rents. Greaker and Lindholt (2019) present no analysis of rents in general and resource rents in particular and simply assume profits are rents. While Flåten and Pham (2019) present some analysis of rents, we found this analysis to be flawed and inconsistent with the economic theory of rents. Essentially ignoring their own theoretical analysis, Flåten and Pham (2019) then siomply measure profits and call the result resource rents.

Both studies presents estimates of an economic "surplus" or profits in aquaculture. However, as we have detailed above, this "suplus" or profits is not economic rents. Moreover, as measures of economic profits, the estimates provided are also flawed. This is becaue they rely on accounting data which ignores key economic values such as the opportunity cost of holding permits and stock of fish in the pens and numerous other intangible assets. Moreover, inframarginal profits which often constitute a large part of total profits are not even mentioned in Greaker and Lindholt, while they are "disregarded" by Flåten and Pham (2019) because they do not have the data to estimate them.

The NOU also makes reference to the use of tax data as evidence of the existence of «resource rents» in aquaculture. While we have not had time to look into this, we do not believe it is possible to use such data to estimate resource rent.

8. WEAKNESSES IN THE NOU 2019:18 REPORT

The NOU 2019:18 report (hereafter referred to as "the Report") is long and in many respects quite detailed. Its key empirical finding is that the Norwegian salmon aquaculture currently is highly profitable. The report refers to these profits as rents (in Norwegian "grunnrente") and attributes them, at least to a substantial extent, to the natural resources, more precisely the marine sites, used in aquaculture. The report then recommends that these profits be subjected to special taxation which it claims is economically non-distortive because the marine sites are immovable natural resources that cannot respond to the taxation. Moreover, they claim the number of available sites is limited, not only in Norway, but world wide, without presenting any evidence that this might be the case.

In our opinion, the report suffers from several fundamental weaknesses. The following summarises the main weaknesses we have identified.

1. **The report measures profits not economic rents**

The report defines “renprofit” as supernormal profits ("extraordinær avkastning") and attributes them to superior natural resources (“naturgitte fortrinn”) and regulations [section 1.1 paragraph 5]. It then proceeds to equate "renprofit" with “grunnrente”. The main argument for this terminology seems to be that this is often done [section 1.1. end of paragraph 5], although no references or evidence to this effect are provided. In various other places in the report, it is claimed that natural resources (marine sites) explain a significant part of the "renprofit" or "grunnrente". In this way it is suggested that the "renprofit" in salmon aquaculture to a significant extent, or at least economic rents, are attributable to natural resources.

In economic theory, however, economic rents and economic profits are two different concepts (see section 4). Moreover, in quantitative terms, they are generally not equal. Either can be larger than the other. In well-behaved situations, however, rents would be smaller than variable profits with the difference being so-called infra-marginal profits (see section 4).

It follows that what the Report calls "grunnrente", being a variant of profits, is not at all economic rent. Moreover, since "grunnrente" is not economic rent it cannot be assumed to exhibit the special properties that are often associated economic rents.

In our opinion, it is misleading to refer to the profits in Norwegian salmon aquaculture as economic rents and even more misleading to refer to them as natural resource rents. This can also be said also about the studies by Greaker and Lindholt (2019) and Flåten and Pham (2019) that the Report use as “evidence” for the existence of rents. However, the estimates these reports present are measures of profits, not rents. It is important to bear in mind that these studies are largely based on accounting profits. Moreover, the opportunity costs of permit values and the stock of fish is not taken into account in the estimation of profits. This means that the estimates of economic profits are seriously misleading.

2. The measured profits are not only or even primarily generated by natural resources

The Report repeatedly attributes "renprofit" to the natural resources used in aquaculture. However, as explained in sections 4 and 5 above, the profits are the result of all the variables that enter the profit function of the aquaculture firms, including physical capital, human capital, technology, know-how, organisation, product development, marketing channels, transportation, company innovation, enterprise and leadership as well as product awareness, demand and prices and so on. It is all these factors in combination that generate the profits. Moreover, they are all necessary for positive profits in the sense that a minimum amount of all of them is required to obtain these profits. Therefore, there is no logical basis for singling out one of these factors, such as the natural resource use, as the only or even the main source of the profits. In fact, as explained at some length in section 4.2.2 above, when profits depend on more than one factor, it is generally not possible to assess the relative contribution of any one of them to the observed profits.

Actually, in some passages the Report acknowledges that the observed profits are due to numerous factors in addition natural resource including regulations. Nevertheless, in several other passages, it seems to forget this and lapses into attributing the profits exclusively or primarily to natural resources. This is especially notable when the report tries to justify special taxation of salmon aquaculture on the basis that it is based on the use of a natural resources belonging to the entire nation and that this taxation is non-distortive because the profits stem from an immovable natural resource.

3. The report seems to assume that the aquaculture industry is in equilibrium.

In a fast growing industry, not least one that is based on great technological advances like salmon aquaculture, periodically profitability tends to very high. Indeed, the industry is fast growing because the profitability is high. The social function of this high profitability is to signal to economic agents to bring new entrants and capital into the industry as fast as is economical so the people can enjoy the fruits of the technological advance to the greatest possible extent. However, as the opportunities of the new technology are gradually exhausted and increased supply catches up with the demand, profits tend to decline and converge to normal profits. Well-documented modern examples of this process are various sectors of the IT-industry. The salmon aquaculture industry may well be yet another example. If that is the case, the current high profitability in Norwegian aquaculture is passing through a high profits disequilibrium phase which in due course will converge to normal profitability equilibrium as the global supply expands and close substitutes are developed. In this case, the currently high profits have very little to do with the natural resources given by the aquaculture sites used by the industry (which are plentiful around the world) and, therefore, do not provide a reason to impose special taxation on the industry. In fact, special taxation may easily reduce Norwegian share of the market and global profits during this transient economic bonanza. Moreover, in its fairly brief history since the early 1980s, the industry has been through several booms and busts, including periods when many firms ended up in bankruptcy. High profits are also important so as to increase the solidity of the industry which will make it is better able to withstand a downturn.

4. Tax on rents is economically distortive.

Contrary to what is asserted in the report, tax on aquaculture rents is economically distortive. The Report argues that because the marine sites used by aquaculture are immovable natural resources they cannot be affected by the proposed taxation. This argument, however, misses the crucial point that many other production inputs are controllable by the aquaculture companies and these will inevitably be adjusted so as to maximise the retained profits, i.e., profits net of taxation. In fact, as is formally shown in appendix C, tax on economic rents is generally economically distortive. Moreover, depending on the level of taxation and production conditions, it is shown in appendix C that the distortion can easily be very substantial.

As further discussed in chapter 6, taxation of economic rents in salmon aquaculture is likely to affect the use of flow inputs such as feed as well as the timing and length of the production cycles (rotation), the extent and composition of investments, entry and exit decisions and so on. Moreover, to the extent that profitable production sites are available in other countries (notwithstanding claims in the Report, environmentally suitable sites do exist abroad), special rent taxation may lead to more of the industry being placed abroad.

It is also the case that a special tax will spur the development of alternative technologies. Some of these, such as land based, are likely to be located in or near large consumer markets. This would not only cause a reduction in Norwegian market share, but also lower value added than otherwise and very likely also reduced profitability.

5. Actual impact on government revenues

A key rationale for the report's proposal of a special tax on aquaculture profits is to generate more government revenues. However, as we have seen, rent taxation is economically distortive. Therefore, its imposition will reduce the value-added in the aquaculture industry. Moreover, through supply chains, it will also lead to distortion in other industries and thus likely also reduce their value-added. Through distorted investments, these impacts will become more pronounced in the long run. For these reasons, it is not at all clear that the special taxation on salmon aquaculture proposed in the report will actually increase government taxation revenues. Development of alternative technologies and greater expansion of salmon aquaculture abroad will also contribute to lower taxes from sea-based aquaculture than otherwise. As explained in appendix D, there are two opposing impacts at work here: A higher tax rate will increase government revenues; reduced value-added due to the distortive impacts of the taxation will reduce it. Therefore, the net outcome, both in the short and long run, is a matter of empirical investigation. This investigation is not undertaken in the Report. In this regard, the report seems to rely completely on its untenable presumption that special taxation of salmon aquaculture will have no impact on the operation and development of the industry.

6. Using regulatory restrictions to create a tax base

The Report's proposal that salmon aquaculture be subject to special taxation is partly based on the observation that production permits (and possibly other restrictions on production) have become valuable. This draws attention to a thought-provoking scenario: A profitable industry (in this case salmon aquaculture) emerges. For reasons having primarily to do with other interests (e.g. various environmental considerations), the industry is subjected to production restrictions. These reduce the total profits generated by the industry (although not necessarily those of already existing companies) and harm salmon consumers (although not necessarily in the long run). With binding production restrictions, permits to produce become valuable, i.e., regulatory rents are generated. Pointing to this ("unearned") value, special supplementary taxation is imposed on the industry. The end result is that the industry is hurt twice. First, by the production limitations, second by special additional taxation, in effect justified by the the production limitations causing the initial damage.

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APPENDICES

APPENDIX A: DERIVING AN EXPRESSION FOR ECONOMIC RENTS

Adopting the generalised definition of rents in the main text (see also figure 3.2), denote the quantity of the variable by *q*. Let the other relevant variables (such as prices, natural resource stocks, capital, entrepreneurship, knowledge, marketing channels, technology and so on) be expressed by the vector $\boldsymbol{z}$. The we can write the (inverse) demand for the variable *q* as:

$$p = D(q, \boldsymbol{z}),$$

where *p* denotes the demand price. It is useful to note in this context that if the variable is used for production purposes, $D(q,\boldsymbol{z})$ represents the marginal profits of using the variable *q*. In other words, $D(q,\boldsymbol{z}) = \Pi_q(q,\boldsymbol{z})$, where $\Pi(q,\boldsymbol{z})$ represents the profit function (Varian 1984). Note that in terms of figure 3.2, the marginal profit is price less marginal costs. When, on the other hand, the variable is used directly for consumption $D(q,\boldsymbol{z})$ would be proportional to the marginal utility of consuming the factor, $U_q(q,z)$ (Varian 1984). Given this, rents associated with the variable *q* may be expressed in any of the following three ways:

(A1) $R(q,\boldsymbol{z}) = D(q,\boldsymbol{z}) \cdot q = \Pi_q(q,\boldsymbol{z}) \cdot q = U_q(q,\boldsymbol{z}) \cdot q$.

In what follows, in order to focus on essentials, we will in what follows consider rents in production i.e.,

(A2) $R(q,\boldsymbol{z}) = \Pi_q(q,\boldsymbol{z}) \cdot q$

The rents defined in (A1 and A2) should be referred to as "rents associated with the variable *q*". This is because all the variables in the function *D*(.,.) can give rise to rents in a similar way as *q* and therefore it becomes important to refer rents to the variable in question.

Note further that if *q* in (A2) above is not binding, profit maximisation implies that $\Pi_q(q,\boldsymbol{z})=0$ and the rents will be zero.

APPENDIX B: RENTS AND PROFITS

Consider rents as defined in appendix A and chapter 3.1 in the main text. Focus for convenience on rents in production, i.e.

$$R(q,\boldsymbol{z}) = \Pi_q(q,\boldsymbol{z}) \cdot q \,,$$

were $\Pi_q(q,\boldsymbol{z})$ is the first derivative of the profit function with respect to *q*.

If the profit function is sufficiently differentiable (more precisely, at least S^2), an exact Taylor expansion of the profit function around some quantity $\bar{q}$ yields:

$$\Pi(q) = \Pi(\bar{q}) + \Pi_q(\bar{q}) \cdot (q - \bar{q}) + \Pi_{qq}(\hat{q}) \cdot (q - \bar{q})^2 / 2 \text{, some } \hat{q} \in [0, \bar{q}],$$

where for notational convenience reference to the other variables, ***z***, has been suppressed. The above equation holds for any *q* and therefore also for *q*=0. I.e.,

$$\Pi(0) = \Pi(\bar{q}) + \Pi_q(\bar{q}) \cdot (0 - \bar{q}) + \Pi_{qq}(\hat{q}) \cdot (0 - \bar{q})^2 / 2 \text{, some } \hat{q} \in [0, \bar{q}].$$

Rearranging we find:

(B1) $\Pi(\bar{q}) = \Pi(0) - \Delta + \Pi_q(\bar{q}) \cdot \bar{q}$,

where $\Delta \equiv \Pi_{qq}(\hat{q}) \cdot \bar{q}^2 / 2$ is the quadratic term.

For a weakly concave profit (or, more generally, benefit) function which is necessary for profit maximisation (see e.g. Varian 1984), $\Delta \leq 0$. Now, $\Pi(0)$ represents the profits obtained when there is nothing of the variable *q* used. This quantity, thus, equals the negative of what is usually called fixed costs. Thus, presumably $\Pi(0) \leq 0$. With this in hand, we can easily derive the relationship between profits and rents summarized in table B1.

Table B1. Relationship between profits and rents.

	Profit function	
Fixed costs	Linear, $\Pi_{qq} = 0$	Strictly concave, $\Pi_{qq} < 0$
Positive ($\Pi(0) < 0$)	$\Pi(q) < \Pi_q(q) \cdot q$	?
Zero ($\Pi(0) = 0$)	$\Pi(q) = \Pi_q(q) \cdot q$	$\Pi(q) > \Pi_q(q) \cdot q$

Thus we see that economic rents can be either greater or smaller than profits. In particular, in the most plausible situation, i.e., a strictly concave profit function and positive fixed costs, the relationship is indeterminate. More precisely it depends on the relative magnitudes of the fixed costs and the curvature of the profit function represented by Δ. Let Φ represent this difference, i.e., $\Phi = \Pi(0) - \Delta$. Then, if Φ>0, $\Pi(\bar{q}) > \Pi_q(\bar{q}) \cdot \bar{q}$, and vice versa.

The relationship between variable profits, i.e., $\Pi(\bar{q}) - \Pi(0)$, and rents is much more straight-forward. Inspection of equation (1) shows that variable profits are always greater than or equal to rents provided the profit function is at least weakly concave. More formally

$$\Pi(\bar{q}) - \Pi(0) \geq \Pi_q(\bar{q}) \cdot \bar{q}$$

The equality applies when the profit function is linear, i.e., Δ=0. If not, (3) shows that variable profits equal the sum of rents and infra-marginal profits with the latter being expressed by -Δ which is a nonnegative. More formally (B1) implies:

(B2) $\Pi(\bar{q}) - \Pi(0) = \Pi_q(\bar{q}) \cdot \bar{q} - \Delta$.

Interpreting the demand curve in figure 3.1 as marginal profits, this figure illustrates the message of (B2), namely the equality of variable profits to the sum of rents and infra-marginal profits.

APPENDIX C. DISTORTION OF ECONOMIC RENT TAXATION: THE SIMPLE STATIC CASE

Consider a continuous and smooth (differentiable) unmaximized profit function $\Pi(x)$, where x is a vector of inputs and outputs, prices and other variables affecting profits.

Normally, the firm will seek to adjust the variables in this profit function so as to maximize its profits. This gives rise to the necessary condition for profit maximization:

$\Pi_{x(i)}(x)=0,$ all controllable x_i in x.

Assume that a subvector x_1 of x is constrained such that $x_1 \leq \bar{x}_1$ and that this constraint is binding. Profit maximization then implies:

(C1) $\Pi_{x_1}(\bar{x}_1, x_2) > 0$,

(C2) $\Pi_{x_2}(\bar{x}_1, x_2) = 0$,

where the differentiation is over the two subvectors, respectively. Note that (C2) defines profit maximizing(or optimal) solution for the x_2s conditional upon the constrained variables.

The first set of necessary conditions, (C1), implies the existence of rents associated with each of the constrained variables defined by:

$R(\bar{x}_1, x_2; i) = \Pi_{x(i)}(\bar{x}_1, x_2)\cdot \bar{x}(i)$ for all $x(i) \in \bar{x}_1$.

Note that the rents depend on all the variables on which the profit function depends including the controllable ones.

Under rent taxation, the firm is faced with the following problem:

$\underset{x_2}{Maximize}\ \Pi(\bar{x}_1, x_2) - \tau\cdot\Pi_{x_1}(\bar{x}_1, x_2)\cdot\bar{x}_1 \equiv \Pi(\bar{x}_1, x_2) - \tau\cdot R(\bar{x}_1, x_2)\cdot\bar{x}_1$,

where τ is a vector of rent taxation rates with the property that $1\geq\tau(i)\geq0$ and $\Pi_{x_1}(\bar{x}_1, x_2)$ is the corresponding vector of derivatives.

The solution to this maximization problem includes the necessary conditions:

(C3) $\Pi_{x_2}(\bar{x}_1, x_2) - \tau\cdot\Pi_{x_1,x_2}(\bar{x}_1, x_2)\cdot\bar{x}_1 \equiv \Pi_{x_2}(\bar{x}_1, x_2) - \tau\cdot R_{x_2}(\bar{x}_1, x_2) = 0$.

Comparing (C2) and (C3) shows that the rent taxation generally distorts the use of the controllable variables unless in the unlikely case that the cross-derivatives $\Pi_{x_1,x_2}(\bar{x}_1, x_2) \equiv R_{x_2}(\bar{x}_1, x_2) = 0$ for all x_2. This observation proves the fundamental distortion theorem:

Theorem

If the firm has any controllable variables, taxation of economic rents generally distorts its use of these variables.

Since condition (C2) maximizes the firm's profits, the rent taxation reduces these profits and therefore almost certainly the region's NDP (Net Domestic Product).

The distortion caused by rental taxation is normally toward lesser use of productive inputs. To see this, consider how the taxation impacts the optimal use of controllable variables. Condition (C3) describes the optimal use of controllable variables. The impact of altering the taxation rate on the use of these variables is given by the differential:

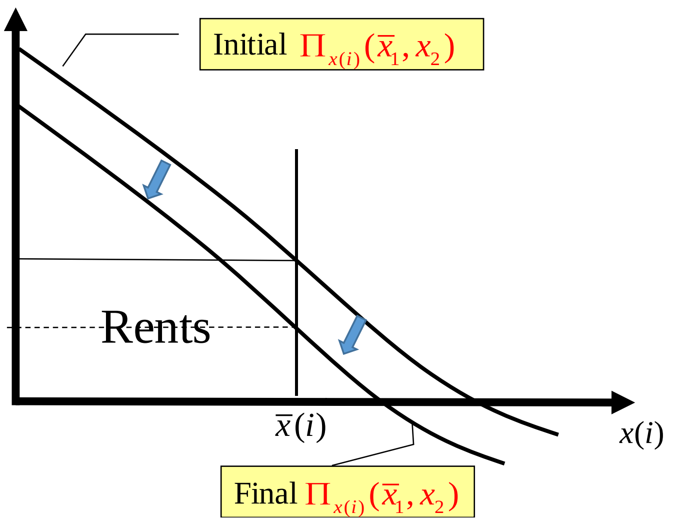
$$\left[\Pi_{x_2,x_2}(\bar{x}_1,x_2)-\tau\cdot\Pi_{x_1,x_2,x_2}(\bar{x}_1,x_2)\cdot\bar{x}_1\right]\cdot dx_2=\left[\Pi_{x_1,x_2}(\bar{x}_1,x_2)\cdot\bar{x}_1\right]\cdot d\tau$$

The sign of the bracketed term on the left hand side is almost surely negative. The first second derivative is negative by profit maximization (concavity of the profit function in the neighbourhood of maximum). The second term is, given our assumptions so far, indeterminate. However, for the entire bracketed term on the lhs to be positive, this second term ahs to be even more negative than the first. A little analysis based on common functional forms suggests this is highly unlikely. The term on the right hand side is positive for productive inputs (those that increase the marginal profits of the others). Therefore, $\partial x_2/\partial\tau<0$. In other words: An increase in the rental taxation reduces the use of productive inputs. This is, of course, what one would expect a priori.

What happens to profits and rents may be graphically illustrated as in figure C1. The distorted use of controllable variables normally shifts the marginal profits curve for the restricted variables down. In figure C1, the initial or non-taxed situation yields the upper marginal profits curve for the restricted variable *x*(*i*). With rent taxation, the x_2 vector is modified shifting the marginal profits curve down. This distortion obviously reduces profits (the area underneath the marginal profit curve from zero to $\bar{x}_1$) and, as illustrated, also reduces the rents.

Figure C1

Distortion due to rent taxation



To reduce their rent tax, the companies would primarily adjust the x_2 variables that have the greatest effect on marginal profits and least effect on profits. Beforehand, it is difficult to guess what these variables would be. However, these variables might include R & D (research and development), innovation, product development, marketing effort and so on.

Since rent taxation distorts the use of variables that are not constrained, it is useful to be mindful of the following:

1. At a certain level of rent taxation rate (easily far below unity), the constrains on one or more of the constrained variables may cease to be binding. At this point the rents associated with this variable vanish.
2. At a certain level of rent taxation rate (easily far below unity), retained profits go to zero and it is optimal for the company to cease operation.
3. There is generally a level of rent taxation rate that maximizes rental tax revenues.

A numerical example

To illustrate the above theory, it may be useful to consider a simple example.

Let the production function be a simple Cobb-Douglas of two variables

$$q = x_1^a \cdot x_2^b,$$

where x_1 and x_2 are inputs.

It should be mentioned that while in the Cobb-Douglas form both inputs are necessary for production, there is a considerable degree of substitutability between them[37]. While this substitutability may be unrealistically high for many natural resource use, the point of this exercise is merely to illustrate the basic theoretical point of the distortion of rent taxation.

The unmaximized profit function is:

$$\pi = p \cdot x_1^a \cdot x_2^b - w_1 \cdot x_1 - w_2 \cdot x_2,$$

where p, w_1 and w_2 are market prices.

The following values of the parameters are assumed:

Parameters	Values
a	0.5
b	0.42
p	3
w_1	1
w_2	1

Given these specifications, it is straight forward to compute the following results:

[37] For the Cobb-Douglas function, the elasticity of substitution is unity.

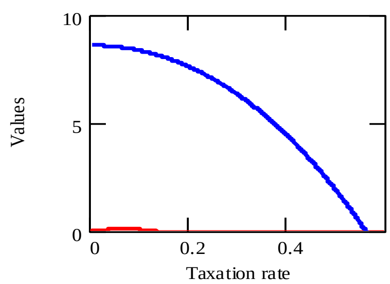
Constraints	Taxation rate, τ	x_1	x_2	Profits	Retained profits	Tax revenue	x_1-rents	x_2-rents
None	0	63.5	53.4	10.18	10.18	0	0	0
$x_1 \leq 30$	0	30.0	28.0	8.60	8.60	0	3.28	0
$x_1 \leq 30$	0.0575	30.0	25.2	8.52	8.41	0.108	1.88	0
$x_1 \leq 30$	0.1	30.0	23.3	8.36	8.27	0.083	0.83	0

The results reported in the above table show (i) that a constraint on one variable alters the use of the other variable (is distortive); (ii) that rent taxation distorts the use of the other variable; (iii) that rent taxation reduces total benefits from the activity and (iv) that there is a rent revenue maximizing rent taxation rate, namely 0.0575.

The dependence of activity profits (before tax) and taxation revenue as a function of the taxation rate is illustrated in figure C2. The figure shows that as predicted by the theory the gross profits generated by the industry are monotonically declining in the taxation rate. The taxation revenue, by contrast is initially rising and subsequently falling with a maximum at a certain taxation rate. This is also as predicted by theory. What is striking in figure C2 is how small part of the total profits the maximum rent taxation is. The main reason for this is the interplay between the elasticity of substitution between the restricted variable, x_1, and the unconstrained one, x_1 and the numerical value of the constraint. At a relatively low level of rent taxation (roughly 0.15), the constraint ceases to be binding and rents disappear. This, of course, depends on the functional and numerical specifications of this example and may not be representative of empirical reality in general.

Figure C2

Profits and rent taxation income as a function of taxation rate



APPENDIX D. THE NET IMPACT OF TAXATION ON GOVERNMENT REVENUES

Consider a taxation regime where the basic taxation is on total value-added at the rate t_0. Consider now an additional taxation of one industry, arbitrarily referred to as industry 1 at the rate t_1. Then the tax revenues received by the government (assuming no cost of tax collection) are:

$$T(t_1) = t_0 \cdot (Y_0 + \pi_1 + W_1) + t_1 \cdot \pi_1 ,$$

where Y_0 is value-added in other industries and $\pi_1 + W_1$ is the value-added in industry 1 with π_1 representing profits and W_1 wages.

Then obviously:

$$dT(t_1) = t_0 \cdot (dY_0 + d\pi_1 + dW_1) + dt_1 \cdot \pi_1 + t_1 \cdot d\pi_1 ,$$

where "*d*" denotes the difference operator, so that for instance $dT(.)$ is the change in T.

Now, the only unequivocally positive term on the right-hand-side of this equation is $dt_1 \cdot \pi_1$. In fact, if the taxation is distortive, all the other terms will be negative. It follows that it is an empirical question whether in fact, special taxation of industry 1 will increase the taxation income of the government. Moreover, this empirical study needs to be dynamic because the long run effect may be different from the short run effect.