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Current and future competitiveness of the Icelandic and Norwegian salmon farming industries: A comparison of economic performance, productivity, and characteristics of the national environments in which the salmon farming companies operate.

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ABSTRACT

While Norway has had a world-leading position in farmed Atlantic salmon since the pioneer age of the 1960s and 1970s, Iceland's history of salmon farming is one of misadventure; however, a third attempt to become a viable player in the global industry is underway. Despite disagreements over terminology and the extent to which each country-specific characteristic affects the success of firms operating within it, economic and strategic management literature generally accepts that aspects of the national environment are explanatory variables when determining competitiveness

This thesis aims to assess the prospects for success of the Icelandic salmon farming industry. Specifically, it aims to assess the industry´s current competitive situation, its potential development, and what country-specific differences are of most interest. Biologic and economic parameters are measured and compared with equivalent data points from Norway found in literature and official sources, using unique data collected from Icelandic salmon farming companies, including annual and generational bioeconomic variables. While current competitiveness is determined by relative cost and price achievement, future development in competitive positions is based on a theoretical and integrated understanding of the cost drivers, which are derived from a systematic and in-depth analysis of biological performance and labor efficiency, as well as the industry's context.

Norway is found to have significantly lower cost over the compared period, while Iceland generally achieves higher prices due to higher slaughter weight and possibly premium prices. Thus, and theoretically, Iceland's current competitive position cannot be determined, whether it is one of competitive advantage or disadvantage. Additionally, it demonstrates that, under equal conditions, 40 percent of the cost difference can be accounted for by differences in labor productivity. The exponential growth rate and lag in production can account for some of this and these effects on labor productivity are expected to decline.

In all, what can be found in this analysis is that the cost disadvantages of Iceland stem from extra transport costs and production time in the sea, which ultimately can be traced to the absence of global competitive suppliers and colder sea temperatures, respectively. As the "startup" costs will decrease and strategic alternatives to circumvent disadvantages, Iceland's salmon farming industry probably has a bright outlook.

Acknowledgments

I want to extend my grattitude to my supervisor, Audun Iversen, for his support and guidance, at all hours, during this project. Your feedback has been very constructive, and motivating.

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I also want to express my grattitude to my informants interviewed in this thesis. The insights you shared were critical in directing the study's approach.

To my family, Hallveig and Kolbeinn: thank you so much for the love and support througout this semester. You have had an extraordinary ability to put things into perspective and encourage me, even when the writing seemed overwhelming.

Tromsø, May 2021

Sverre Vormedal

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1 Introduction

Iceland is now in its third era of conventional salmon farming, and the intensification of Atlantic salmon farming in Iceland has regained traction. With an exponential growth that doubled every two years, starting from 1 thousand tons in 2010, the harvest of farmed Atlantic salmon reached 34 thousand tons in 2020. The expectations for further growth are strong within the industry, and the government has so far issued licenses for 87 thousand tons maximum allowable biomass (MAB). However – and what implicitly can be interpreted from the fact that they are in their third era – conventional salmon farming in Iceland has not been successful before. Genetically disadvantages, biological problems and/or monetary circumstances have been pointed out as the major causes of industry collapse in 2000 and 2008 (Bjarnason & Magnusdottir, 2019; Gudjonsson & Scarnecchia, 2009; G. S. Gunnarsson, 2018; V. I. Gunnarsson, 2008).

Is it likely that Iceland will succeed this time? This question has not been examined before, and the literature on Icelandic aquaculture is seemingly limited to topics of coastal zoning and the legal framework that regulates the industry (e.g., Bjarnason & Magnusdottir, 2019; Solås et al., 2020; Young et al., 2019). Moreover, since Iceland is an open economy that takes part in world trade, the prospects of conventional salmon farming in Iceland must rely on the operators' ability to compete internationally.

Competitiveness is however a broad term that has several dimensions to it, and depending on theoretical standpoints, this can be measured and approached in various ways. One that famously proclaimed to provide a universal framework for assessing countries' competitiveness in specific industries is the Harvard Business School professor Michael Porter.

In 1990, he published "Competitive advantage of Nations," an ambitious work that attempts to combine the academic fields of international trade theory and strategic management theory to explain sources of industry success and national prosperity. According to this theory, the level of the international success of an industry is determined by country-specific traits in the firm's "home base," such as intra-industry competition, skilled labor, demanding home customers, and the presence of suppliers and related industries. Furthermore, Porter defined the international success of the industry of a nation as to whether or not it processes "competitive advantage relative to the best worldwide competitors." Thus Norway, being the biggest producer of Atlantic salmon and considered one of the most productive salmon farming nations globally (Iversen et al. 2020), is chosen as the country of comparison.

Using Porter as a methodological guide, and in conjunction with other conceptions of competitive advantage in economic and strategic management theory, this thesis aims to assess the Icelandic salmon farming industry's prospects for success by benchmarking against Norway.

These research questions were created to help direct the analysis:

1. What is the current competitive situation for Icelandic salmon farming in terms of price and cost achievement?
2. How much of the (potential) differences in economic performance can be explained by country-specific advantages?
3. What is the potential future competitive position of the Icelandic salmon farming industry?

The continuing structure of the thesis is outlined in the following order:

Chapter 2: Theoretical framework

Here, theories in international economics and links to business strategy theories are reviewed. A thorough summary of Michael Porters' theory on the competitive advantage of nations (1990) and his analytical framework "Diamond Model" will be provided.

Chapter 3: Method and materials

The analytical framework is presented in this chapter, along with a presentation of the data sources used in each analysis stage and information on the data collection method.

Chapter 4: Context

A description of the impact factors, primarily natural conditions, is provided, as well as the history and regulation of the country's industry.

Chapter 5: Proposition:

Interview perceptions are presented and analyzed in light of theory and context in order to develop hypotheses for the current study

.Chapter 6: Analysis

Here, production statistics, economic performance, biolocical productivity and labor efficiency measures will be presented, analyzed, compared and discussed in order to answer the research questions

Chapter 7: Conclusion

In this last chapter, key findings will be summarized and the research questions will be answered

2 Theoretical framework: comparative vs. competitive advantage

Competitiveness is a broad term that can be applied in many different settings, and even in the economic and business understanding of the term, there are a variety of definitions and theories on how to achieve competitive advantage. This chapter will try to clarify conceptual differences and present the theoretical foundations considered when answering the research questions. Approaches and concepts of competitiveness will first be reviewed categorically by the two academic fields of strategic management theory and international trade economics.

2.1 International trade economics (macro perspective)

2.1.1 Absolute advantage

In “Wealth of Nations” (1776), Adam smith examined the underlying causes of the general and universal increase in wealth following industrialization. With an allusion to his previous work, “Theory of Moral Sentiments” (1759), smith describes trade from the starting point of our inherent self-interest and endowed skillsets. In combination, this incentivizes exchanges of mutual benefit, leading to specialization and division of labor in all levels of society. Also globally. In the same way as the butcher and the baker benefits from mutual trade and productivity gains from their endowed skills, and how specialization and cooperation increased labor productivity in the pin factory, these mechanisms will also be played out among nations. As a result, he asserted that countries should specialize in manufacturing and exporting products that can be produced more efficiently than those produced by other countries. This theory, known as “absolute advantage,” argued against what he referred to as the “mercantile system,” which was the economic policy that had dominated European nations since the Renaissance. Mercantilism views international trade as a zero-sum game and used import tariffs and export subsidies to achieve a positive trade balance, and the market participation was heavily reliant on having royal privileges.

2.1.2 Comparative advantage

Like Adam Smith, David Ricardo was a supporter of international trade and a critic of the mercantilist policies. However, he was not fully satisfied with Smiths’ thesis on “Absolute advantage,” as it did not explain what happens if a country has an absolute advantage in all trade goods (Cho & Moon, 2008). Implicitly, according to Smith, it would not be beneficial to trade. Ricardo (1817; as cited by Cho & Moon, 2008) proposed his "Comparative Advantage" theory, arguing that even though one nation has an absolute advantage in all products, trade will still be advantageous if the superior nation focuses on the product with the greatest absolute advantage, while the inferior nation focuses on the product with the least absolute disadvantage. Countries should specialize in products of the lowest *opportunity cost.*

While the input factors in Smith and Ricardo's models were limited to labor costs, Hecksher-Ohlin provided a more extensive international trade theory focusing on factor endowments. In Morrow (2010), he explains that the HO models claim that disparity in comparative advantage derives from differences in factor abundance and the relative proportions of various factors used in producing the goods. More detailed: *"... Heckscher–Ohlin predicts that countries will produce relatively more of the goods that use their relatively abundant factors relatively intensively.*" (Ibid.). This model would then project that capital-rich countries would export commodities that were more capital-intensive than labor-intensive. However, the theory failed the empirical test carried out by Wassily Leontief as his 1953 study found that the exports from the wealthy United States were less capital intensive than its imports. These results are known as the *Leontief Paradox.*

While Leisner, in his 1958 work, pioneered the concept of measuring a country's 'strong' sectors through an analysis of actual export flows, Bela Balassa (1965, 1989) refined and popularized the technique after that (Hinloopen and Marrewijk, 2001). Balassa developed an index model that quantifies a country's comparative advantage or disadvantage in a particular product or group of products, as evident by its share of national exports in relation to the commodity's share of observed global trade flows.

$$(1) \quad RCA_{aj} = \frac{X_{aj}/X_a}{X_{gj}/X_g}$$

Where

$RCA_{aj} =$ Revealed comparative advantage indecx of country a in industry j

$X_{aj} =$ Country a's export value of industry j,

$X_j =$ Country a's total export value of all goods,

$X_{gj} =$ Total global trade of industry j's product,

$X_g =$ Total global trade

This index is recognized as the Balassa-index or, alternatively, the “revealed comparative advantage”-index as the actual export flows “reveal” the country’s strong sectors. It is a common metric for identifying a country’s strong industries, but it does not explain the underlying causes.

2.2 Business and industry strategic management theory (micro)

In strategic management theory, the focus on competitiveness is related to the firm’s ability to compete within an industry under more realistic assumptions than used in neoclassical theory. Within this study field, there are many theories on achieving and sustaining competitive advantage, but two main directions that distinguish them apart can be recognized: (1) the corporate environment perspective and (2) the resource-based view of the firm.

2.2.1 Environment perspective

The most important work within the corporate environment perspective of competitiveness can be ascribed to Michael Porter and his “five forces”- model. In his 1979 and 1980 articles, he presented an analytical framework for assessing a firm’s competitive position within the industry environment

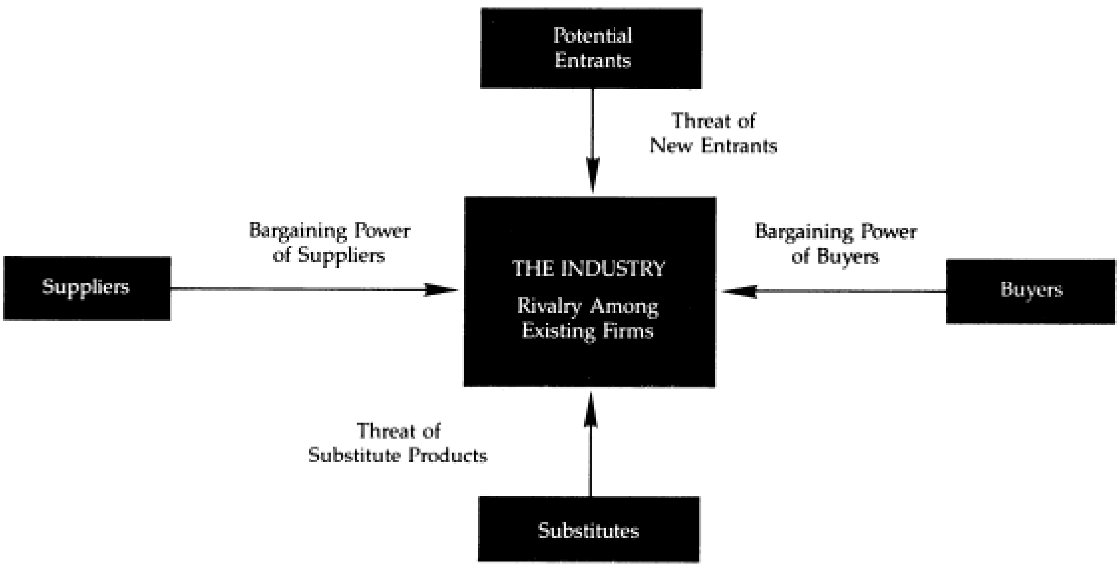

Figure 1 The five forces model. Adapted from Porter 1980

The main objective of the model is to help leaders to identify threats in the industry environment. These threats are described as forces that increase competition in the industry and drive the firm's productivity towards normal profit. The five threats that can jeopardize the company's ability to maintain or create competitive advantage are by Porter identified as:

- Internal competition in the industry
- Substitutes
- Possible newcomers
- Bargaining power of customers
- Bargaining power of supplier.

(1) The threats of intra-industry competitors are related to the actions and applied strategies of the rivals. Competitor knowledge, marketing positioning, and creativity are all possibilities that a business must tackle.

(2) The threat of substitutes is determined by the accessibility, amount, and price of alternative products. Customers are less price-sensitive when there are no alternatives, and businesses may charge higher prices for their goods. While an abundance of available substitutes makes customers more cost-sensitive, an increase in the actual product price or a decrease in the price of a substitute causes customers to flee.

(3) The threat of possible newcomers is related to the threshold of entering the industry. Porter argues that an industry's return on investment will be moderated either directly or indirectly by price reductions caused by new operators or by fear of new operators entering the industry. However, if entry barriers exist, current operators can maintain a high-profit margin – depending on the magnitude of the entry barriers – without having to worry about new entrants. Capital intensity, economic scale, and government restrictions can all act as entry barriers.

(4) The customers are considered a competitive threat based on how price sensitive they are and their bargaining power relative to the producer. Price sensitivity is related to how differentiated the products are and how the customer weighs price and quality. Relative bargaining power concerns the concentration and size relation between the customer and producer, information level, and the customers' ability to integrate vertically.

(5) The threat of suppliers' bargaining power and the supplier-producer relation will logically be subject to the same competitive forces described in the producer-customer relation.

Porter views industry structure as the main determinants of how competitive and how profitable industry is. Companies within an industry with few or no threats are considered to have a competitive advantage.

2.2.2 Resource-based view

Porter's five forces model has been criticized for being too simplistic in its attempt to prescribe optimal strategies to remedy complex problems. It allegedly has limited power to explain intra-industry performance differences as it, for example, does not adresses why some companies achieve high profits in unfavorable and highly competitive industries. In Barney's review of the environmental model (1991), he points out some fundamental assumptions that are neglected or under-evaluated. He further professes that the environmental model overlooks the impact of heterogeneity of company structure and the firm's internal resources. Moreover, he claims that there has been little emphasis on the limitations of resource mobility and uncertainties.

In the resource-based view, dominated by the works of Wernerfelt (1984), Peteraf (1993), and Barney (1991; 1996), performance is determined by the characteristics of the resources that a company possesses (as cited by Dreyer and Grønhaug, 2004). To gain a competitive edge over its rivals, the business leaders must assure that skills, capabilities, and other resources are distinct from those of its competitors. If businesses have the same quantity and mix of resources, they cannot use different strategies to outcompete one another, as others can simply replicate the actions of one, and no one can enjoy a competitive edge. The second premise of RBV is that resources are immobile and do not move between companies in the short run. If a company's resources were completely mobile, outsiders could easily enter the industry. This would violate the heterogeneity assumption, resulting in no one gaining a competitive advantage.

However, not all resources can give *sustained* competitive advantage. The capacity of a resource to *sustain* a company's competitive advantage is determined by the following criteria outlined in Barney (1991):

It must be valuable. A valuable resource is defined as a resource that enables a company to develop or implement strategies that improve its productivity

It must be rare. Competitors and potential rivals can not have the same valuable resources. Competitive advantage is only attained by utilizing resources and strategies that are not implemented by many others.

It must be hard to imitate. The valuable and rare resource can be a source of sustained competitive advantage when it becomes difficult for those not to obtain such resources.

Strategic substitutes must be absent. Different but equally valuable resources that either are nonrare or imitable cannot be available. If a sufficient number of firms possess these valuable substitutes or a sufficient number of firms can purchase or develop these valuable resources, nobody can achieve sustained competitive advantage.

2.2.3 Hunt and Morgans comparative advantage theory of competition

According to Hunt and Morgan (1995), competitive advantage occurs when a company's *resource* composition is: (1) more cost-effective to produce than comparable options from competitors, (2) it enables it to offer a product or service to a *market* that is perceived to have a higher value, or (3) a combination of both. This approach is a hybrid of the previous two in that resources can be used to create a competitive advantage and that it is positioning-oriented. According to Hunt and Morgan, a company can be placed in nine different competitive positions, which they illustrate with a matrix.

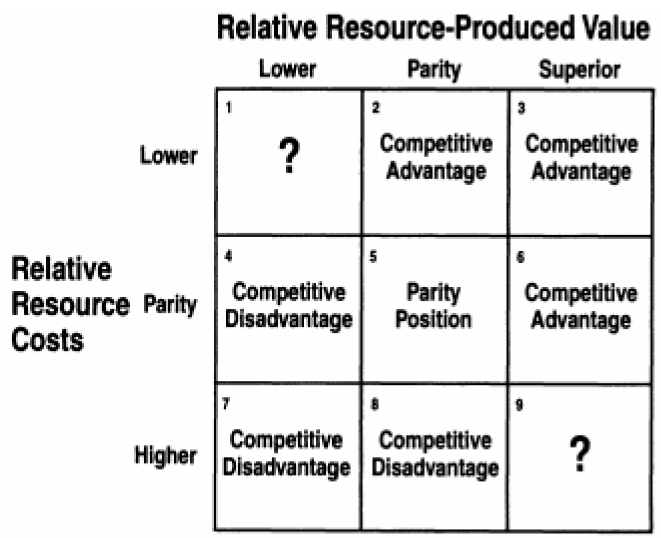

Figure 2 Competitive position matrix. Adapted from Hunt and Morgan (1995)

2.3 Porters Diamond Theory

In the book “Competitive advantage of nations,” published in 1990, Michael Porter claims that prosperity in developed nations does not stem from a country’s national endowments, such as labor, raw materials, or the level of interest rates or currency values, as the established economics theories of “comparative advantage” would claim. Instead, he argues that it is created and dependent on the capacity of a country’s industries to innovate and upgrade, which in turn is stimulated by the pressure on companies to compete. According to Porter, an advantage is achieved by finding a new basis for competing or finding more efficient ways of competing in the traditional sense. Furthermore, gained advantages are often the result of an accumulation of lots of small insights rather than major breakthroughs, usually involving investment in skilled labor and other assets. Innovation, though, is a result of unusual effort, and to sustain the gained advantage needs constant upgrading. Companies need stimulation to innovate and upgrade.

Porters’ research on national competitive success patterns demonstrates that rather than being successful in every industry sector; a country excels in a few. He cites the following examples: Germany’s high-performance automobiles; Japan’s semiconductors; Switzerland’s pharmaceuticals; and Italy’s footwear. In studying the national attributes that lead to these specific sectors succeeding, he identified four determinants of national competitive advantage. These make up the famous diamond model.

These determinants are; (1) factor conditions; (2) demand conditions; (3) related and supported industries; (4) firm strategy, structure, and rivalry.

The mentioned determinants shape the national environment in which the companies are established and developing in order to compete. Each element, and the system as a whole, determine whether or not critical skills, resources, and information are obtainable. It also affects company owners and managers’ goals, and more importantly, it impacts the pressure on companies to invest and innovate.

These are the core of Porters'diamond; however, two more factors are also assumed to affect the determinants indirectly, namely "the role of government" and "chance events."

2.3.1 The core determinants

Factor conditions: According to traditional economic theories, trade flow is determined by factors of production such as labor, property, natural resources, capital, and infrastructure. And by making the most of the factors in which the nation is endowed, it leads to national prosperity. However, he argues that it is not the inherited factors that matter for sophisticated industries but those it creates through sustained heavy investment and specialization as primary resources can be obtained through trade or by utilizing technology. For Porter, competitive advantage rests on a nation creating specialized industry-specific factors and continuously upgrading them.

Along with the presence of advanced specialized factors, Porter emphasizes how the absence of fundamental factors can encourage an organization to innovate and upgrade. Where there is an abundance of inexpensive inputs, businesses may rely on those advantages and very often use them inefficiently. On the contrary, when a firm is faced with shortages of resources such as land, labor, or raw materials, it must innovate to stay competitive. To illustrate this, he uses the example of Japan, where land is scarce and expensive. Japanese businesses responded by reducing storage levels and work in progress, which contributed to the development of "just-in-time" production. The necessary skills to address challenges must be present, and firms must be forced to confront the issue by competitive pressure.

Porters' second determinant is *demand conditions:* This focuses on the composition and character of the home market, not the overall market size. According to Porter, firms gain a competitive advantage because demanding buyers pressure them to innovate faster and achieve more sophistication than their foreign rivals.

Related and supporting industries: Porter finds that global competitive home-based supplies create advantages in downstream industries in two ways: Firstly, they provide the most cost-effective inputs, sometimes more rapidly and preferentially to domestic clients. Secondly, and more significantly, the proximity of such supplies leads to closer working and constant flow of information that stimulates innovation and upgrading. The interaction is mutually advantageous and self-reinforcing.

The fourth and final determinant is *firm strategy, structure, and rivalry:* Porter is here referring to national circumstances and context and their impact on how businesses are formed, organized, and managed, as well as on how they compete. Furthermore, he is referring to the institutional system and not to specific company strategies.

He argues that the combination of management strategies and organizational modes preferred in that country is among the factors that contribute to an industry's competitiveness. Additionally, he claims that the different institutional systems will better fit the needs of some industries than others. To illustrate, he uses the following example: German management system and patient capital closely match the needs of technical or engineering-orientated industries; in contrast, a large pools of risk capital and a short-term focus as in the US is better fitted with software and biotechnology industries.

In terms of rivalry, he argues against the conventional notion: that domestic competition is wasteful, and the right approach is to embrace one or two national champions. According to Porter, these national champions are often uncompetitive due to government subsidies and protection. Domestic rivalry is needed to pressure companies to innovate, push each other to lower costs, improve quality and create new products and processes. Unlike rivalries with international rivals, local rivalries often turn into highly personal, active feuds as participants compete for market share, people, technical leadership, and bragging rights. His point is that with true domestic rivalry, the companies cannot hide behind unfair advantages; there are no excuses. Domestic players are in turn driven to look to global markets for greater productivity and profitability as a result of intense competitive pressure.

2.3.2 The Role of Government

Many believe that governments have a key role in supporting specific economic competitiveness goals; in direct contrast, the free-market supporters assert that the market's "invisible hand" should handle the economy. For Porter, both views are incorrect and lead to the erosion of nations' competitive capabilities. Direct support reduces the stimulus to innovate and upgrade, while diminished involvement ignores the legitimate role the governments play in shaping the context and the institutions that influence firms' competitiveness. He stresses that governments cannot create competitive industries; only companies in competition can do that. Act as the catalyst and challenger that pushes companies to raise performance. So, governments need to transmit and amplify the determinants of the diamond model. Porter lists the following advice for the government:

Firstly, he says that governments should focus on specialized factor creation, such as advanced developments tied to specific industry clusters through university research, trade association activities, and stimulating private investments. Secondly, they need to avoid intervening in factor or currency markets, as this allegedly reduces the pressure on firms to innovate and operate. Also, strict product safety and environmental standards should be enforced as it will pressure domestic companies to improve and – if anticipating global standards – gain an advantage.

2.3.3 The Diamond in System

According to Porter, the diamond should be regarded as a system, with each point reliant on the state of the others. The weakness in one will constrain the industry's potential, but equally strong elements will reinforce each other. A strong diamond indicates that a country rarely has only one competitive industry; rather, the diamond facilitates clusters of industries connected by vertical and horizontal relationships, often geographically concentrated.

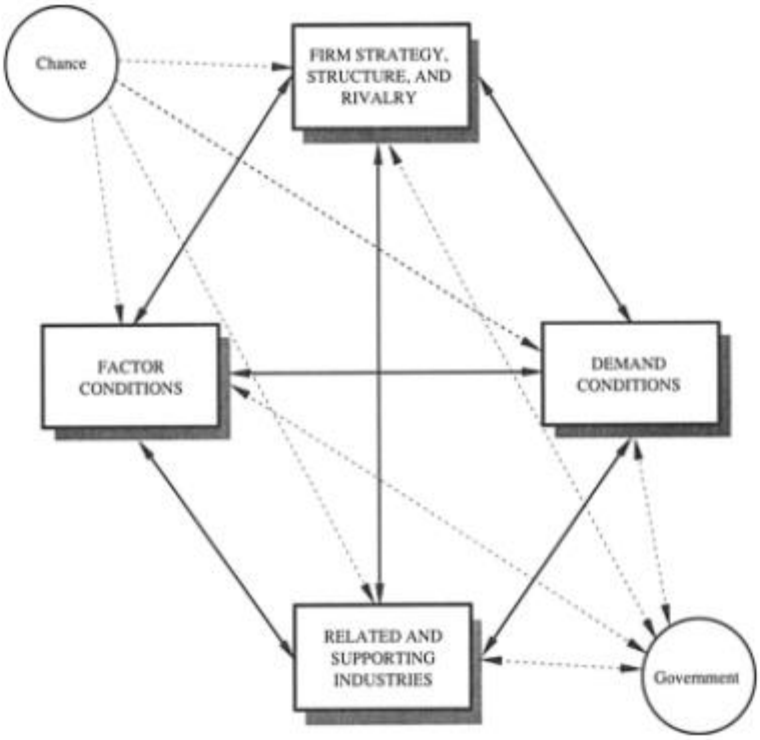

Figure 3 The complete diamond system. Adapted from Porter (2011, p.166)

3 Materials and methods

In this chapter, we will explain the methodological approaches for the thesis. This includes a description of the research design, analytical components, and conceptual clarification of used definitions.

3.1 The general and conceptual approach

By comparing aspects of their national environments and several productivity metrics, this study seeks to define and clarify the competitiveness of the countries and the underlying causes of similar or dissimilar economic performance. While theories such as the diamond model propose a universal framework applicable to all industries, such analysis will in fact, be extensive and will also necessitate an in-depth understanding of the mechanisms and characteristics unique to the industry.

According to Yin (2012), studying phenomena over time, in-depth, and studying contextual relations, are all common characteristics of case studies and are the conditions that will lead to a great mismatch between numbers of variables of interest and numbers of available data points. The "data at hand" will always restrict such studies. As the aims of this study check off for all these conditions, we can categorize the study as belonging to the case study methodology. Moreover, this study can be considered a comparative case study with multiple units of analysis, where the cases compared are the two salmon farming industries of Norway and Iceland in the context of their national environment.

The emphasis on triangulation, finding rival explanations, and making an "open" logical argumentation account for much of the validity of this design. In complex situations, this allows us to recognize key variables, processes, and relationships (Yin, 1994; as cited by Rashid et al., 2019).

This study focuses on industry competitiveness and the underlying sources in the national environment that can explain current and potential economic performance of the countries salmon farming companies. As the theory section suggests, there are several interpretations and dimensions of the term "competitiveness," as well as its relationships to the terms competitive and comparative advantages. Concepts and definitions outlined in; Porter's "diamond-model" (1990), Hunt and Morgan (1995), Balassa (1965; 1989, as cited by

Hinloopen and Marrewijk, 2001), and Barney (1991); will be used together or seperately in the different stages of analysis in this study:

Comparative vs. competitive advantages:

To meaningfully distinguish between the terms competitive and comparative advantages, competitive advantages refer to when they are absolute or based on strategic business decisions; otherwise, comparative advantages will be used.

Current competitiveness:

Conceptually, we measure the current competitiveness of the salmon industries by its current *competitive position* of the firms within the industries. Based on Hunt and Morgan (1995), this is the status quo economic performance, which in turn is determined by the relative cost and price the industries achieve. Competitive advantage, competitive disadvantage, and parity are the three competitive *positions* that can be obtained.

Future competitiveness:

The disparity between the companies' current competitive positions can be explained by their used and unutilized comparative advantages. Future competitiveness will then be determined by the difficulty of capitalizing on comparative advantages, and how difficult it is to circumventing/maintain any of the disadvantages/advantages that contribute to the current competitive position.

3.2 Detailed approach

As this is a case study, the context is an integral part of the analysis. In this case, the context is the Icelandic and Norwegian salmon farming industries and their respective national environments. However, a comprehensive examination of all of those aspects would exceed the scope of this thesis. To keep this to a manageable level while still gaining useful insight, the interview data with experts in Norwegian and Icelandic aquaculture are used to initiate an analysis of relevant country-specific differences. This analysis happens in Chapter 5, where the informants' perceptions of the most significant impact factor that could account for differences in economic performance are analyzed in conjunction with the context chapter and Porters' "diamond" theory. This constitutes the propositions for how the current competitive situation looks

Research question 1:

1. What is the current competitive situation for Icelandic salmon farming in terms of price and cost achievement?

This question will be determined by the cost per kilogram of salmon produced and the price achieved. This metric is based on Hunt and Morgan (1995), and the results will be presented in the same competitive position matrix shown in their article

Price achievement is evaluated based on the average weight as that is positively correlated with the market price. Production costs are the annual total operational costs divided by kg head-on gutted (HOG) salmon. The production costs for Norway are collected from secondary sources, mainly the Norwegian Directorate of Fisheries (NDF) 2003-2019 productivity survey and financial statements of the top five stock listed companies[1] from 2016-2020. The top five companies were used to estimate Norway's 2020 production costs[2]. It is also an interesting comparison because salmon farming companies in Iceland are also publicly listed.

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[1] The Norwegian segments of MOWI, Salmar, Lerøy, Grieg and NRS

[2] Production costs per kg in 2020 are estimated as the productivity survey for 2020 is not yet published by NFD. The prediction was based on the average relationship between the top 5 stock-listed operators and the productivity survey for production costs in 2016-2019.

A unique data set with annual and generational economic and biological data has been collected. The data set is limited to four years and three generations, from 2016 to 2020 and 2016 to 2018. However, the data set is collected from companies that account for most of the production in Iceland. The economic variable in this set is operational EBIT/kg.

For price determination, generational average weights has been used because they are the most precise data available in Iceland. Iceland may also obtain premium prices, but no consistent pattern was discovered in financial statements, and thus the decision was made to use the NASDAQ salmon price index for Iceland. Costs are then calculated for each company in Iceland using the weight category price minus EBIT/kg, and then a weighted average based on production share is calculated to represent Iceland[1]. When compared to the NDF survey, this method produced a fairly similar result for the top five companies in Norway. If, on average, Icelandic companies achieve a higher price than the market for their weight category, this implies that Iceland's costs per kg are higher than those measured here.

Research question 2 and 3:

2. How much of the (potential) differences in economic performance can be explained by country-specific advantages?
3. What is the potential future competitive position of the Icelandic salmon farming industry?

Examining the possible future competitive position of the Icelandic salmon farming industry is difficult because there are infinite variables to consider. It requires some understanding of the relationship between the forces that drive the costs and how they impact the cost categories. For Norway, extensive work has been done to understand this, and a conceptual model has been developed to describe these relationships in Iversen et al. (2015)

[1]The same method was used to find production costs of the top 5 cstock listed companies, and the results were very similar to NDF, and was therefore assumed as a viable approach for estimating the production cost pr kg for the Icelandic companies aswell.

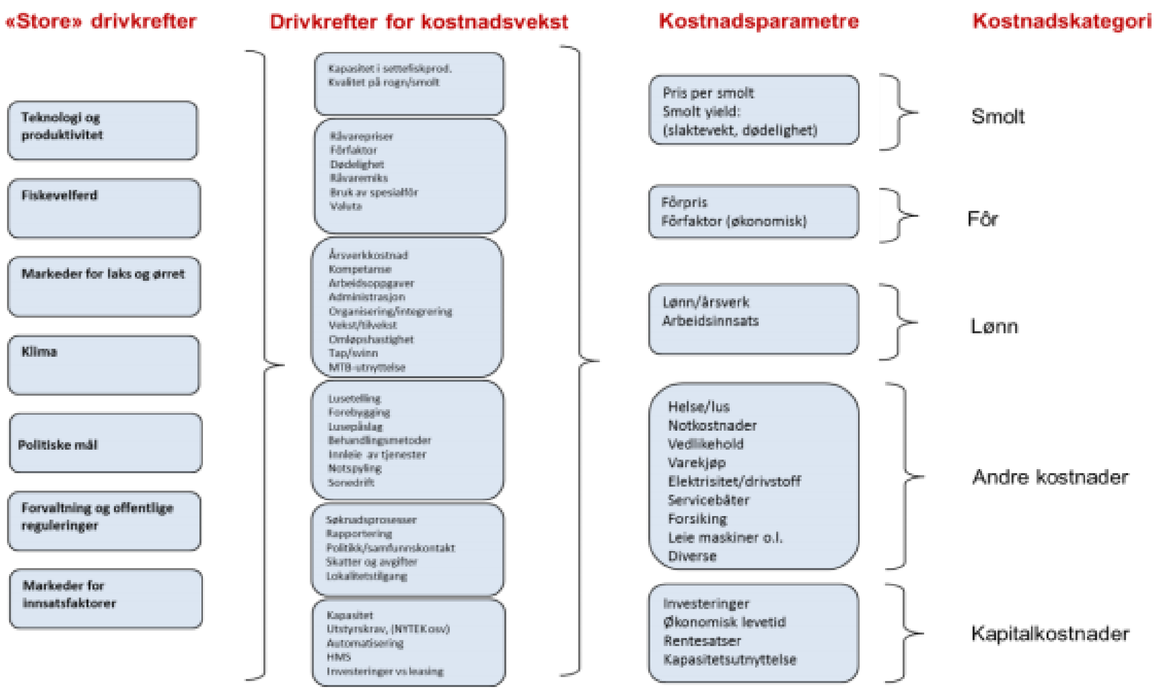

Figure 4 Relationship between cost drivers and cost categories in Atlantic salmon farming. Adapted from Iversen et al., (2015)

As this model illustrates, the relationship between cost parameters and impact factors cannot be quantified precisely, highlighting the study’s limitations in establishing causality.

By country specific advantages,

In Iversen et al., (2020), they assess the competitiveness and production cost development of the five major salmon farming countries by analyzing and comparing cost parameters from a series of generations on smolt yield, production loss (individuals), and economic feed effiicency rate to annual time series data on total production cost and specific cost categories.

This thesis intends to analyse similar parameters and techniques, but specific cost category data for Iceland is not available; instead, an experimental technique is used to isolate the effect of biologic performance and labor productivity on the cost categories by holding all unit prices the same, benchmarking for the Norwegian data. This will then be used to determine how much of the potential difference in economic performance is explained by country-specific advantages. A more detailed description is found in the “what-if” analysis chapter (6.5.1).

When this is done, the holistic view of all findings and insights will be combined in order to assess the prospects of the potential future for Icelandic salmon.

3.3 Data

The data in this study can be classified broadly into two types: quantitative and qualitative. The table below summarizes the quantitative parameters calculated in this study, along with the data source and collection method. Following that, the qualitative data will be listed along with an explanation of how the interviews were conducted.

Table 1 Quatitative parameters: description, source and collection method.

Parameter	**Description**	**Data source**	**Collection method**
Total production	Total production of Atlantic salmon in Iceland, Norway and Globally. Measured in WFE.	SFS (2020), Statista (2020), NFD (2020)	Collected digitally
Production costs pr kg	Operational costs in EUR devided by kg slaughtered HOG salmon – NASDAQ price minus operational EBIT/kg	Anonymous company data (2021), financial statements of Icelandic and Norwegian stock listed companies, NFD (2020)	Collected through personal communication, and digital collection
Average slaughter weight	Slaughtered HOG biomass divided by numbers slaughtered – Smolt yield divided by share of released smolts that are slaughtered (generation)	Anonymous company data (2021), Iversen et al. 2020	Collected through personal communication for Iceland, and fetched graph values for Norway through http://www.graphreader.com/
Smolt yield	Kg. harvested salmons (HOG) per released smolt (generation)	Anonymous company data (2021), Iversen et al. 2020	Collected through personal communication for Iceland, and fetched graph values for Norway through http://www.graphreader.com/
Loss in production	Presented in percentages and is measured by the difference in numbers of slaughtered and released smolts per generation.	Anonymous company data (2021), Iversen et al. 2020	Collected through personal communication for Iceland, and fetched graph values for Norway through http://www.graphreader.com/
Economic feed conversion rate	The accumulated weight of feed used, divided by the weight of harvested salmon (HOG) per generation	Anonymous company data (2021), Iversen et al. 2020	Collected through personal communication for Iceland, and fetched graph values for Norway through http://www.graphreader.com/
Labor efficiency in kg	Annual production in kg divided by employees	NFD (2020), and SFS (2021)	Collected digitally
Labor efficiency in smolts	Annual smolt releases divided by employees	NFD (2020), and SFS (2021)	Collected digitally
Revealed comparative advantage index	Salmon export share of national exports divided by global salmon trades share of the total value of global trade. See Balassa in theory	SFS (2020), Statista (2020), NFD (2020), SSB (2020), Statistics Iceland (2020)	Collected digitally

The qualitative data used in analyzing the salmon farming competitiveness of Iceland and Norway is listed below:

- Interviews
- Legislation
- Academic books, journal articles, and reports
- Information in financial statements
- Official reports

Four key informants, selected through the strategy of purposeful sampling (Palinkas et al. 2015), were interviewed in this study. They were selected for their relevant knowledge and insight in both industries, and they have a different professional and national backgrounds. The interview questions were tailored to their field of expertise or occupation, and they were allowed to illustrate and describe the key factors that they believe account for possible productivity variations between the countries. Although the interviews were unstructured in general, each interviewee was asked at least one question that was identical to the others. We exercised caution with the interview data's significance due to the limited selection, but the interview data was useful in triangulating with other sources and in creating propositions.

4 Context

4.1 Production of Atlantic salmon

According to Hindar and Jonsson, and Knapp et al. (1995; 2007), the cultivation of salmonoids has its roots in early European attempts from the mid-eighteenth century. Around two hundred years went by before the Atlantic salmon was successfully cultivated in net pens. Today, farmed Atlantic salmon is the second most valuable aquaculture species by total value, with an estimated production value of 16,7 billion USD in 2017 (Cai et al., 2019). The total production in 2019 was around 2,7 million tons (Statista, 2020).

Producing Atlantic salmon effectively is and has historically been a technological challenge. The Atlantic salmon is a relatively slow-growing species in nature, and its physical environment is constantly threatened by external factors such as weather, disease, and algae blooms. Conventional farming of Atlantic salmon occurs in open net pens in temperate and sheltered coastal areas in the North Atlantic and eastern Pacific oceans.

Hydrographic conditions:

As the Atlantic salmon is a poikilothermic (cold-blooded) animal, sea temperature and other environmental parameters will significantly affect biological processes such as the growth rate (Karlsen et al., 2018). According to Brett (1979, as cited by Vikeså, Nankervis, and Hevrøy 2017), the temperature is the essential biophysical factor that controls growth, affecting oxygen levels and metabolism.

Identifying an exact optimal temperature for cage farming of fish is a complicated exercise as the environment is constantly changing and the relations among environmental factors are complex (Johansson et al., 2009). When looking isolated at it, the optimum temperature between 13.6 and 11 degrees, decreasing with the size of the fish (Handeland et al., 2008). In Elliot and Elliot (2010), the lower critical survival temperature for Atlantic salmon is pointed out to be at -0.75 degrees, and the lethal upper limit is suggested at 23 degrees, according to Joblings literature review (1981).

When the temperature in the salmon pens reaches the upper end of the maximum growth range, the appetite and metabolism of the fish increase, resulting in an increase in oxygen consumption. In turn, a decrease in available oxygen leads to increased ventilatory frequency and ventilation volume rate, leading to reduced energy availability for metabolism (Musa et al. 2013). In addition, warmer sea water can hold less oxygen. Furthermore, algae growth on net pens increases with temperature, constraining water circulation and, consequently, affecting oxygen availability. Diseases are also associated with higher temperatures. Many serious infectious diseases and parasites have emerged in intensive salmon aquaculture, such as PD, ISA, and salmon lice. These factors can significantly impact an industry's production costs and productivity through loss in production, feed loss, and lice treatment costs, among other things. A good location includes not only ideal temperatures but also optimal currents and low farm density, which helps to mitigate disease and sea lice threats. Adequate management and monitoring of the industry are also critical, as is access to sheltered conditions for Atlantic salmon farming.

4.2 Norway

In Norway, commercial fish farming (contained culture) of Atlantic salmon started when the Bergen-based company Mowi AS and the Grøntvedt brothers from Hitra set smolts in sea pens in 1969 (Ferguson et al., 2007). Since then, the industry has had tremendous growth and currently stands for around 50% of the global salmon supply with an annual production of 1,35 million tons in 2019 (NDF, 2020; Statista, 2020).

Circumventing biological and environmental problems that has occurred, has by many been attributed development of extensive breeding programs (Gjedrem et al., 2012), vaccination programs (Sommerset et al., 2005), and solid production systems (Lekang et al., 2016). The industry's economic and technological achievement has been celebrated as a success. Erna Solberg, Norway's current prime minister, has even stated that the salmon farming industry is Norway's IKEA (NRK, 2015). There are some truths to this analogy. For example, the Norwegian Salmon farming companies have expanded their production globally, they are vertically integrated, and they are the biggest supplier in the global market.

Natural conditions:

In a decade long time-series (1990-1999) of hydrographic parameter data fetched from the IMR database, it shows zero sea temperature cases under 0 degrees in any of the eight measure stations along the Norwegian coast. The highest observed sea temperature was measured at 19 degrees.

Norwegian coast will typically be described by its numerous islands, skerries and archipelagos. Including fjords and excluding islands, 29 000 kilometer-long coastline (SSB, 2013). With the number of active farms this adds up to an farm density of 30 coast kilometer per active farm in Norway.

There were reported numerous of cases of PD, ISA, IPN, CMS, HSMI, and AGD (Sommerset et al., 2020), and Norwegian salmon and rainbow trout farmers carried out 3361 delicing operations in 2019 (Barentswatch, 20201)

Many academic disciplines specialize in aquaculture in Norwegian educational institutions, and it is offered in a broad range of educational levels; from high school programs, bachelor and master's programs, further education programs for managers, and Ph.D. programs. 32 high schools and 11 universities and colleges in Norway offer fisheries and aquaculture education (FAO, 2011)

Industry regulation:

The Aquaculture Act is the main legislative source that regulates salmon farming and other aquaculture activities. The Ministry of Trade and Fisheries is the principal authority for this Act. Like other industry activities, aspects of the salmon farming industry touch various societal and environmental spheres, such as food safety, animal welfare, spatial planning, infrastructure, pollution, etc. The sectorial government responsible for these laws are other Ministries, underlying government agencies, and local authorities (see figure?).

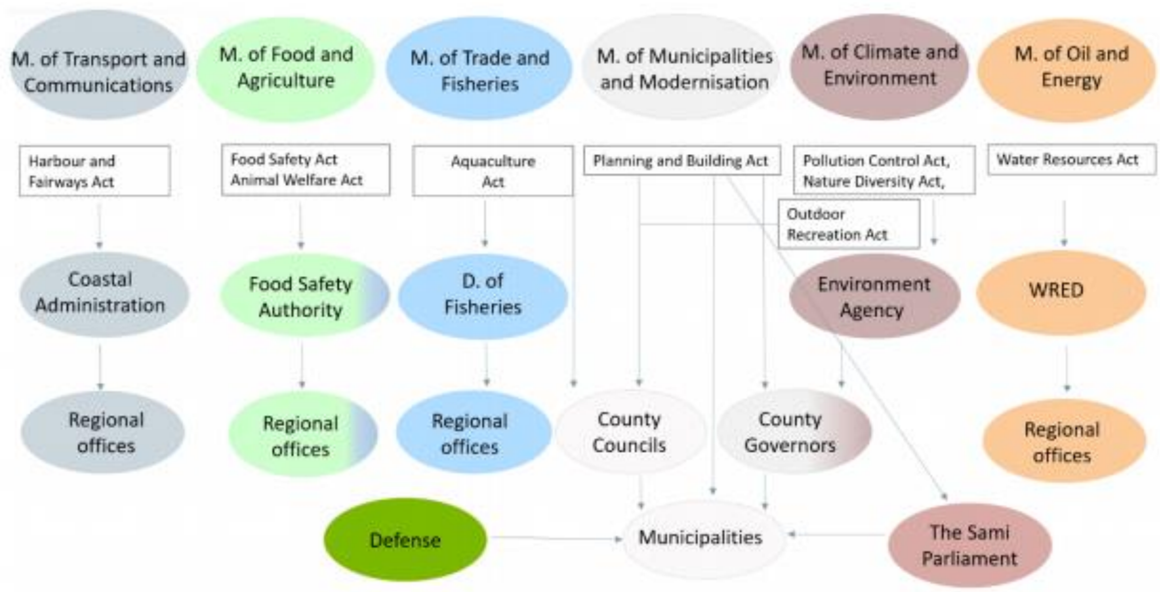

Figure 5 Overview of sector authorities and legislation. Adapted from Solås et al. (2020)

In Norway it is required to have an aquaculture license to produce salmon. An aquaculture license is a right to produce certain species, and this production is bound to a prescribed geographical area. Typically, a locality will have several licenses associated with it, and those licenses will be associated with other localities as well. The main production limitation for a license is the maximum allowed biomass (MAB), which means that the biomass at one site never can at any time exceed the MAB that is confirmed for the specific locations that are tied to the licenses. A standard license to produce salmon is limited to 780 tons for all counties except for Troms, where the MAB limit is 945 tons. Furthermore, producers are obliged to leave the site fallow for at least two months following each production cycle for the site to naturally cleansed for diseases and soiling from feed and fish feces.

On application, the Ministry may grant permits for aquaculture activities. There are two sets of licenses; (1) a licensing promise and (2) an operating license. A license promise is a precondition for applying for the operating license, which the Ministry issues. Issuing an operation license is to clear or approve the location and attach it to a licensing promise or an already existing license. The authority to issue salmon, trout, and rainbow trout license is now delegated to the relevant County Municipality (CM). However, this is more of a coordinative role as the application process must be approved by several sectoral agencies in accordance with applicable legislation.

Issuance of licenses is bounded by the “traffic light system,” a recent regulation that was developed as a reaction to the increasing problem of the industry’s alleged environmental impact from sea lice.

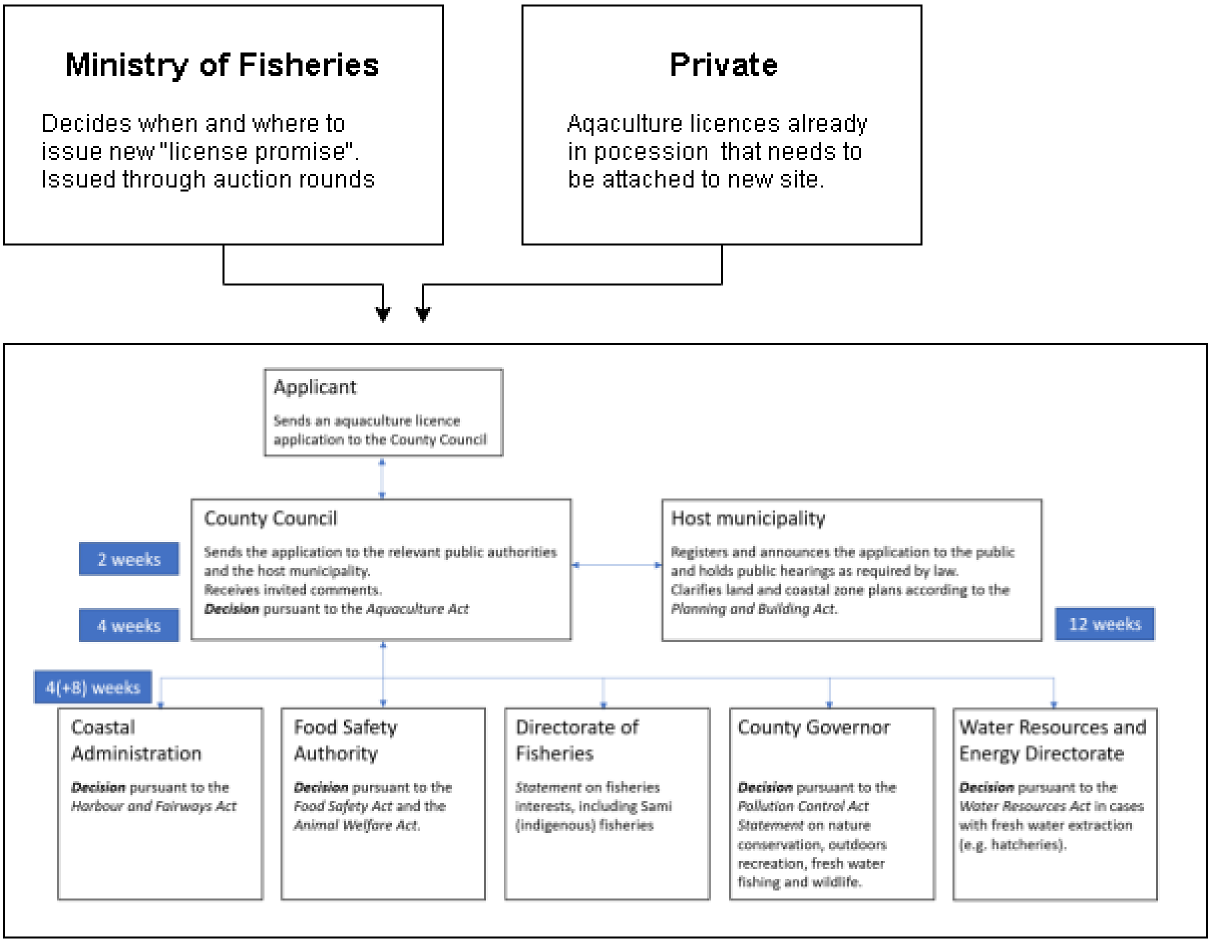

Figure 6 Illustration of aquaculture licensing process in Norway. Modified based on Solås et al.(2020).

In reality, one can say that all the mentioned sector authorities, together with the municipalities, has “veto right” when it comes to clearing the location which is applied for.

A more detailed analysis can be found in Appendix A.

4.3 Iceland

Similar to Norway, Iceland has a long history of Atlantic salmon cultivation. The first attempts of artificial reproduction for stock enhancement can be traced back to the late 19th century. Ocean ranching, commercial and private use of this method for harvesting the returning individuals, has been going on since the 1960s, although only for angling after 1998 (ICES, 2020).

Currently, Iceland is in its third era of conventional salmon farming, which started in 2009 (G. S. Gunnarsson, 2018). The two preceding periods, from 1984 to 2001 and 2001 to 2008, collapsed for various reasons, such as early maturation, diseases, and monetary issues (Bjarnason & Magnusdottir, 2019; Gudjonsson & Scarnecchia, 2009; G. S. Gunnarsson, 2018; V. I. Gunnarsson, 2008). Today, sea site production of salmon is occupied by four companies: Arnarlax, Arctic fish, Icefish, and Laxar fiskeldi. All of them have Norwegian majority owners. Together they produced 32 thousand tonnes in 2020.

The Icelandic coastline is 5000 kilometers long (Central Intelligence Agency, 2021) characterized as being irregular, with fjords –deep and shallow– between the mountain ranges in the western, northern, and eastern parts of the island, while the southern coast is described as *“(...)wide lowlands with a smooth coastline of wide bays and broad lobate promontories”* (Larusson, 2010).

Temperature data for Icelandic waters, as presented in S. Jonsson (1999, 2004), shows sea temperatures below 0 and minus 1 in the Isafjordurdjup production area of Atlantic salmon

Industry regulation:

For Iceland, the primary legislation is the Act on fish farming no.71/2008. Aquaculture on Iceland also touches on a variety of other legal domains and legislations (Solås et al., 2020)

The principal authoritative agencies governed by these laws are essentially the Ministry of Industry and Innovation, the Ministry of Environment and Natural Resources, and the Ministry of Transport and Local Government. A more explicit representation of the sectorial government/law - relations is illsutrated in figure 7.

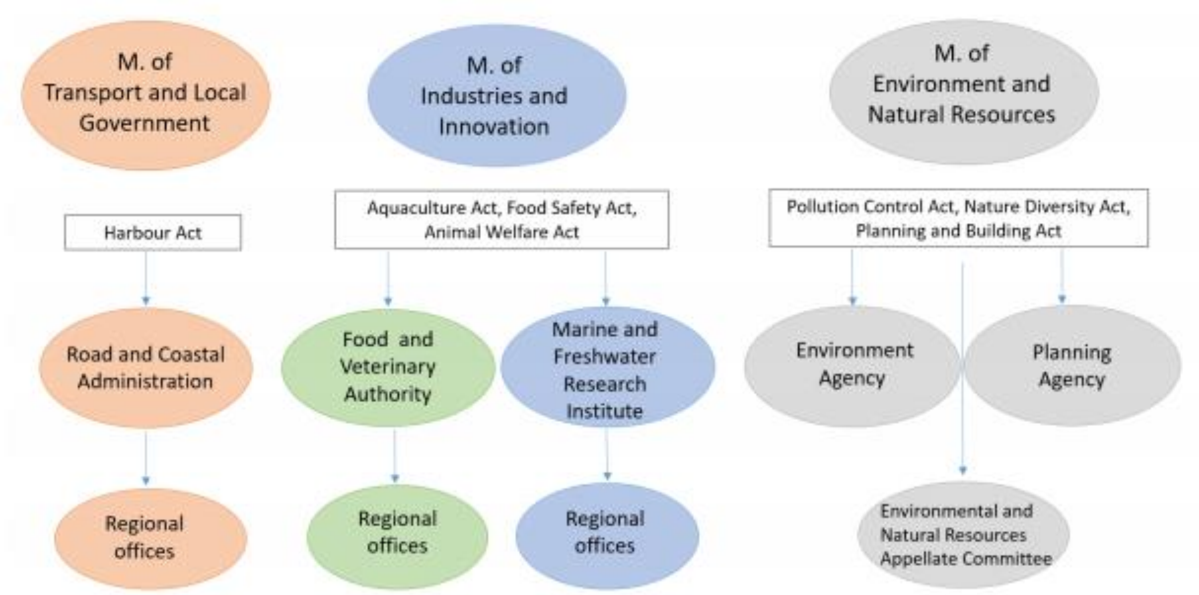

Figure 7 Overview of sector authorities and related legislation for aquaculture in Iceland. Adapted from Solås et al.(2020)

Aquaculture activity in Iceland requires an operating license from the food and veterinary authority (MAST) and an environmental license from the Environmental Agency. Such a license is granted for 16 years. With the current legislation, it is up to the ministry to decide when and to whom aquaculture areas shall be allocated. What areas are available for aquaculture, and the production limit in that area is, however decided by the Marine Research Institute in Iceland (MRI)

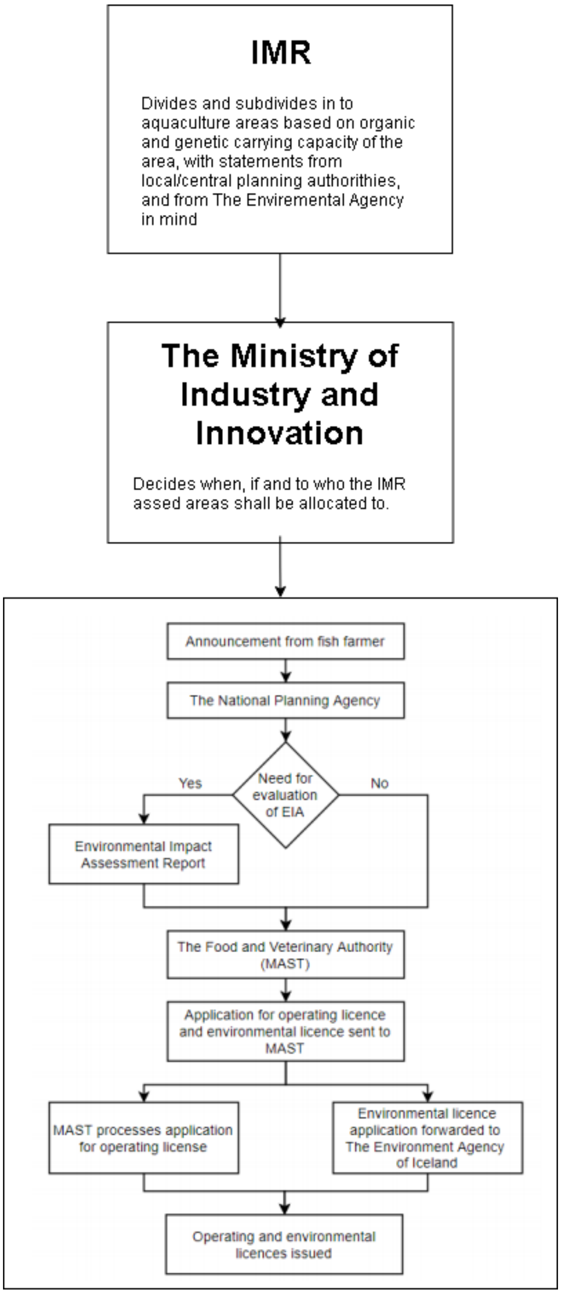

Figure 8 Licensing process on Iceland. Modified from Solås et al.(2020)

By examining the entire system, from zoning to the license application process, one can conclude that each sector authority has a “veto right” over the outcome of new license issuance.

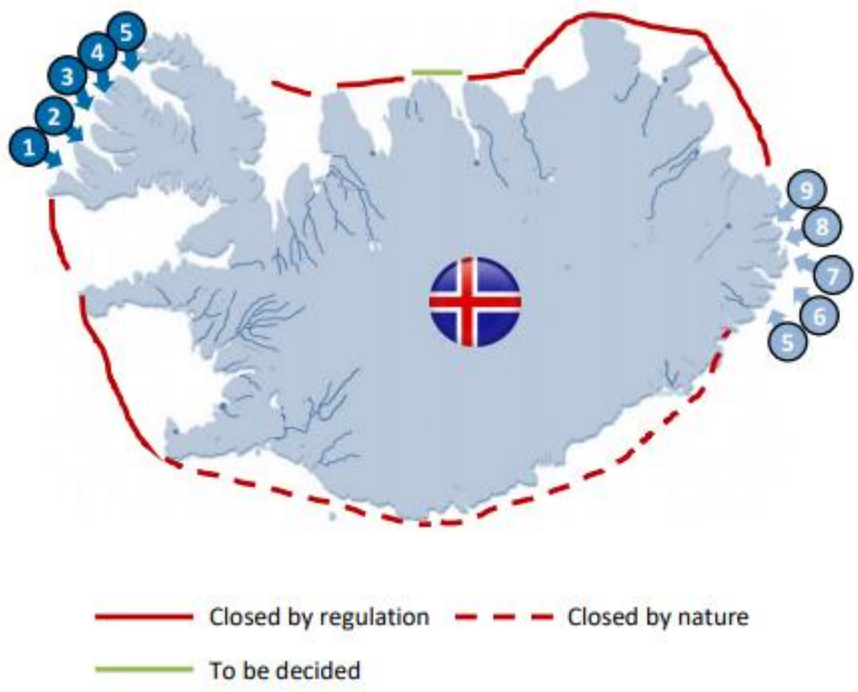

Figure 9 Map of production areas in Iceland. Source: Arnarlax report 2020

Iceland has the excess capacity to issue more salmon licenses. The aggregate MAB of all fertile salmon licenses issued currently sums to 87 700 tons, while the genetical carrying capacity in Iceland is assessed at 100 000 tons. The biological carrying capacity is 127 000 tons.

More detailed analysis can be found in Appendix B

5 Propositions

On the question: *"what could be the single most prominent country-specific traits that might explain variation in production costs between the two countries?"* all informants answered in terms of the disadvantages of Iceland, implicitly assuming that Iceland has a higher cost level than Norway. As the figure below shows, the interviewees perceive the following as primary sources of differences in production costs:

- Experience and know-how
- Absence of suppliers
- Economics of scale
- Public management

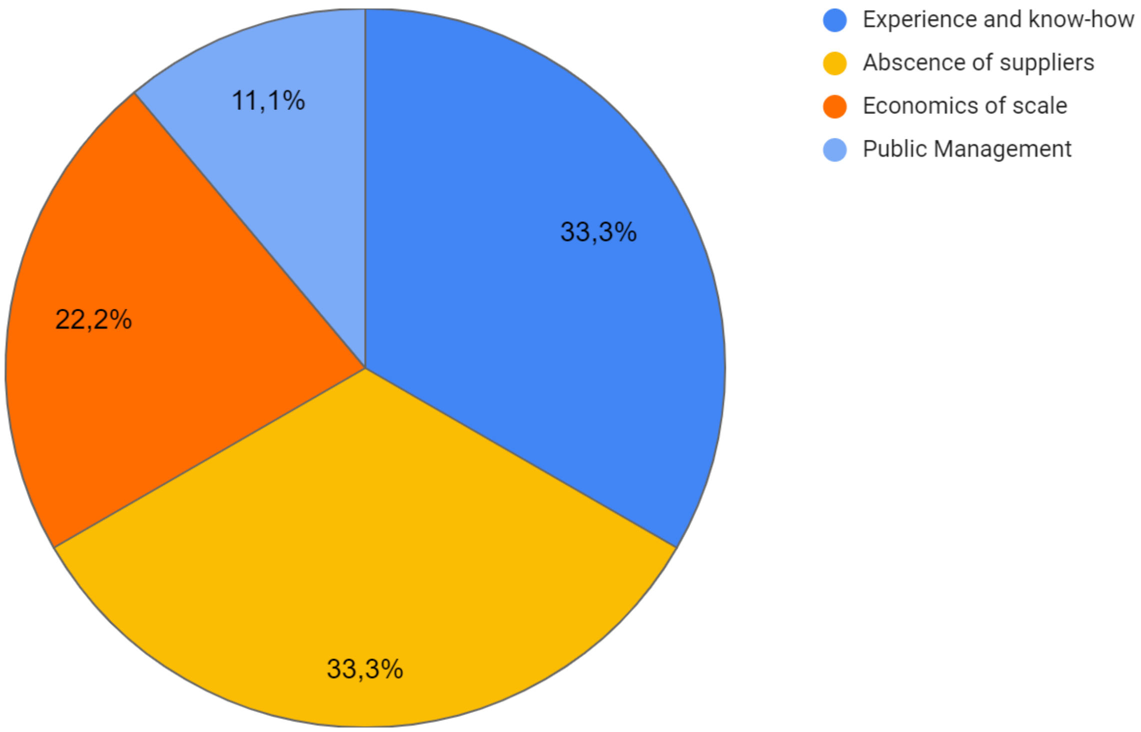

Figure 10 Informant perceptions of the main country-specific disadvantages in Iceland that might explain worse performance[1]

[1] Because all interviewees listed more than one sources, and they seemed reluctant or hestitative to rate the sources, we have chosen to include the two first mentionings

5.1 Economics of scale

It is a fact that Iceland produces on a smaller scale than Norway. However, by looking at the companies, this might not be so evident when comparing the company's production. The lowest annual production of any of the salmon producing companies in Iceland in the period was at 2,7 thousand tons WFE, while the company with the highest production produced 12,6 thousand tons WFE. According to the Norwegian Fisheries Directorate productivity survey (2020), the average production per company in 2019 was 12 thousand tons WFE.

Although, it is generally accepted in economic theory that cost advantages can be derived from the size of operation. As there are fixed costs, the amount that can be produced with the same equipment will impact the cost per unit of output, or as in the salmon farming industry: cost per kg slaughtered salmon. As what determines fixed costs and the amount that *can* be produced will vary from industry to industry, and from country to country.

5.2 Experience and know-how

In economic theory, it is generally supported that skilled labor increases productivity; hence, it is reasonable to believe that inferior competency is reflected in labor productivity and production costs. All informants, to a certain degree, problematized the know-how and experience in salmon farming in Iceland at some stage in the interviews. Having a shorter industry history, along with less relevant educations available, naturally explains the concern. This assumption is in line with Porter, which states that:*" Nations succeed in industries where the skills and resources necessary to modify strategies are present." (2011, 107).* Having more educated and experienced personnel would likely be better equipped to deal with biological challenges and intrinsically lead to better performance for Iceland.

In the processing and distribution channels, Norway might not have the knowledge advantage over Iceland. Iceland is known for being a highly competitive seafood nation and long experience with processing, selling, and distributing diversified products of white fish, and this could be reflected in the costs and possible higher price achievement.

5.3 Absence of suppliers

All interviewees also pointed out the absence of suppliers in Iceland at some stage in the interview. According to Porter (1990), having globally competitive suppliers in the home market will be the most cost-efficient source of supply, and the geographical and cultural proximity between the supplier makes it easier to iterate and bounce ideas off one another, and in turn, generate more knowledge and more sophisticated products.

Informant B reported that Icelandic salmon farming companies imports much of the feed, net pens, feed barges etc., and that this results in an extra transport cost that will be reflected in the production costs per kg. Informant C could tell that the two feed manufacturers in Iceland cannot serve the whole industry. Much of the production equipment is produced in Norway by manufacturers serving a large part of the industry globally. This should in theory, give Norway; cost advantage in unit prices for feed, equipment for smolt and sea production, sea site services, and harvesting, and; knowledge advantage indirectly.

When it comes to the processing side, 2 out of 4 global key vendors (Marel and Skaginn 3x) of fish processing equipment are Icelandic, while only one is from Norway (Optimar)[1]. This could give Iceland a lower unit price for processing equipment

5.4 Public management and legislation

According to Porter (1990), the role of government is to act as the catalyst and challenger that pushes companies to raise performance. One way of doing this, he says is to enforce strict product safety and environmental standards. According to the interviewees, the general rules that the industry needs to comply with within the production seem to be similar, especially when it comes to reporting and documentation obligations. However, the burdens of lice counting and legal limits before delicing is obligatory to seem to be more rigid in Norway.

By revisiting the countries' legislative objectives, one could spot a slight difference in political aspiration for the industry. The Norwegian aim is to *"promote the profitability and competitiveness of the industry within the frames of a sustainable development and contribute to value creation along the coast."* While in Iceland, the wording of the objective is to "*create*

[1] https://www.businesswire.com/news/home/20180119005514/en/Global-Fish-Processing-Equipment-Market-2018-2022---Marel-Optimar-BAADER-and-Skaginn-3X-are-Dominating-the-Market---ResearchAndMarkets.com

conditions for the development of aquaculture and consequently strengthen the economy and the settlement in the country, promote responsible aquaculture and secure protection of wild fish stocks." Although the phrasing suggests a more industry-friendly tone from the Norwegian legislators, one can assume "*industry profitability*" and "*economic strength to for the country*" are two sides of the same coin.

However, the interviewees and the legislative sources suggest that Norway has a more efficient management system that gives Norwegian operators more flexibility.

Both countries have multiple laws and regulations, government institutions, and agencies involved in accommodating the industry, controlling it, and performing services. Norway seems to have the most extensive integration of sectors, which could cause confusion for outsiders and also entail coordinative and cooperative difficulties for the involved agencies and institutions. However, long experience with aquaculture legislation and administrating the industry could ward off such problems, and complying with a complex system more effectively, hence providing a more comprehensive and precise legal framework that meets the objectives of the legislation to a greater degree. In Norway, the application authorities are legally bounded to process the application within 22 weeks, while in Iceland, some applications have been in process for several years. Costs of following up and the planning uncertainty can potentially be reflected in the production costs.

Norwegian salmon farmers' options to combine MAB and attach it to multiple locations are not evident in the Icelandic system. Previous to the new regulation, the companies had to take the initiative and apply for locations and thereafter apply for an operating licence, and the licenses were then fixed to the location (Informant A). And as of now, the opportunity to apply for attaching licenses that are already in possession of the company to another site cannot be found. This demonstrates a potential obstacle for the companies to obtain economics of scale, as a limited opportunity to rotate between locations and generations may result in low utilization of company MAB. This may also lead to low utilization of the determined MAB for the production area, representing a possible economic deadweight loss for Iceland's economy, and somehow contravening the objective of the law.

5.5 Natural conditions

All informants unanimously concluded that the advantages and disadvantages of the countries' natural conditions were balancing each other out in total.

If we look isolated at temperatures, Norway seems to have an advantage over Iceland in that aspect. As shown in the figure, which displays the average seasonal sea temperature profiles for Norway and Iceland, one can tell that the salmon produced in Norway is exposed to a more extended period within, and otherwise closer to, the optimal growth temperature compared to the salmon which are produced in Iceland. Although the average seawater temperatures in Iceland are comparable to Northern Norway, Iceland has more extreme temperatures and a greater risk of cold-related mortality.

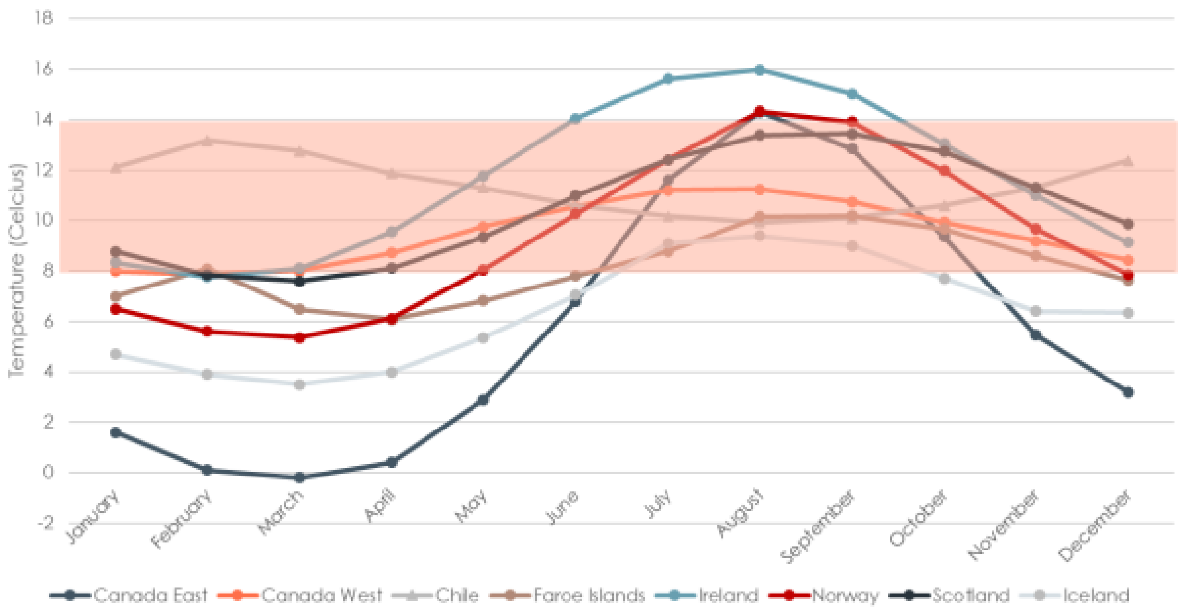

Figure 11: Average monthly seawater temperatures in significant salmon-producing countries. Adapted from Mowi, 2019

Another disadvantage in the natural conditions of Iceland is in its bathymetric and topographic conditions. Being situated in the center north of the Atlantic Ocean, where arctic cyclones are prevalent, sheltered locations are crucial for producing salmon in Iceland. However, when comparing the conditions to Norway, the Icelandic coastline has fewer islands and skerries, more shallow and broader fjord openings relative to the length, which constitutes a higher risk of weather-related incidents and possible scarcity of suitable locations. Nevertheless, according to one of the interviewees, the currently most exposed salmon farm in Iceland is not more exposed than the most exposed site in Norway, with a significant wave height of 4-5 meters. On average, it is reasonable to believe that the conditions are safer in Norway.

On the other hand, Iceland has at least, in theory, more favorable conditions in regards to diseases and parasites. The presence of disease and parasites are, as mentioned, mostly correlated with farm density and temperatures. Fewer farm sites and cold water is an advantage that, along with the abundance of accessible fresh water, geothermal water, and cheap electricity, is, in theory, balancing out the theoretical advantages Norway enjoys by having more optimal growth temperature.

5.6 Working hypothesis

In sum, the preliminary analysis of the national environments held against interview data and theoretical assumptions. The central hypothesis, guiding the further work, is as follows:

1. The salmon industry of Iceland has a competitive disadvantage globally and compared to Norway.
2. The biological performance does not differ between the countries
3. Norway has higher labor productivity than Iceland

The characteristics and future outlooks of the competitive positions of each country will be discussed after.

6 Analysis

6.1 Industry significance

In the figure below, we can see the countries production of salmon every two years since 2010-2020. 2020 for Norway is an estimate based on export reports from Norwegian Seafood Council divided by the 0,95, the approximate share of export.

As we can see in figure 12, the development in Norway stagnated after 2012, but shows a slight increase in the last two years, while Iceland, on the other hand, has had exponential growth and have doubled the production every two years on average.

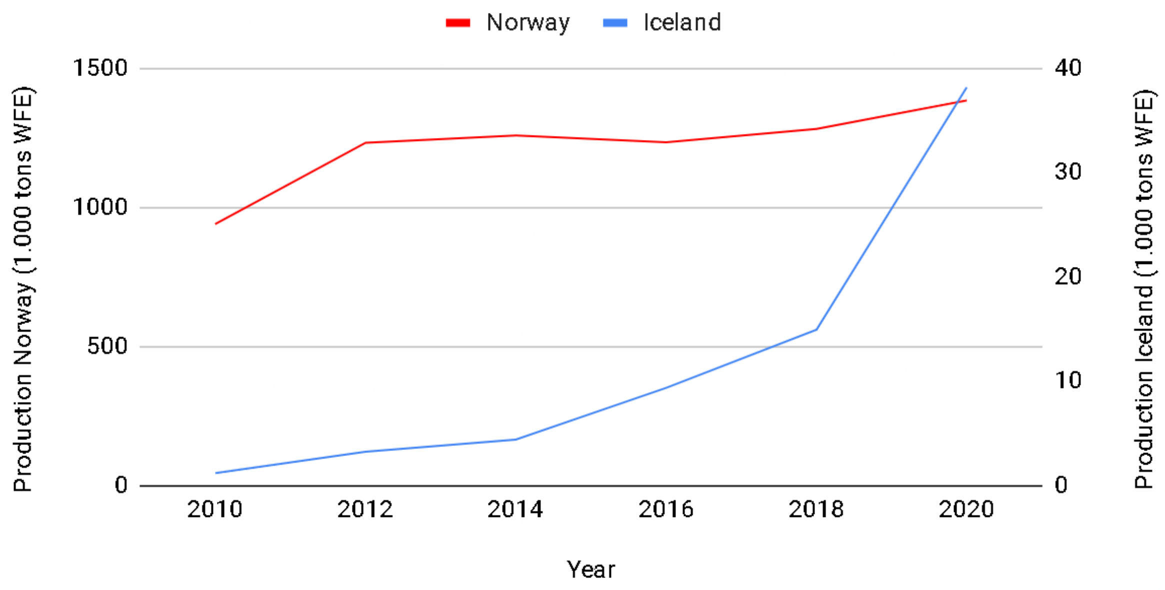

Figure 12 Production of Atlantic salmon in thousand tons WFE between the two countries in 2010-2020. (Source: Norwegian Fisheries Directorate 2020, Norway Seafood Council 2021, SFS 2021)

As the figures below and above show, Iceland is a small producer of Atlantic salmon in comparison to Norway and the rest of the world. Looking at the development of the share of total production over the last decade, we can see that Iceland's share of total production increases, while Norway's share initially decreases before becoming more stable, at just over 50 percent. We can tell by this that Iceland's growth rate is higher than the global growth rate. Norway's decreasing trend in terms of global production share is not the complete picture, as the high share was due to biological issues in Chile around 2010 (Iversen et al., 2020).

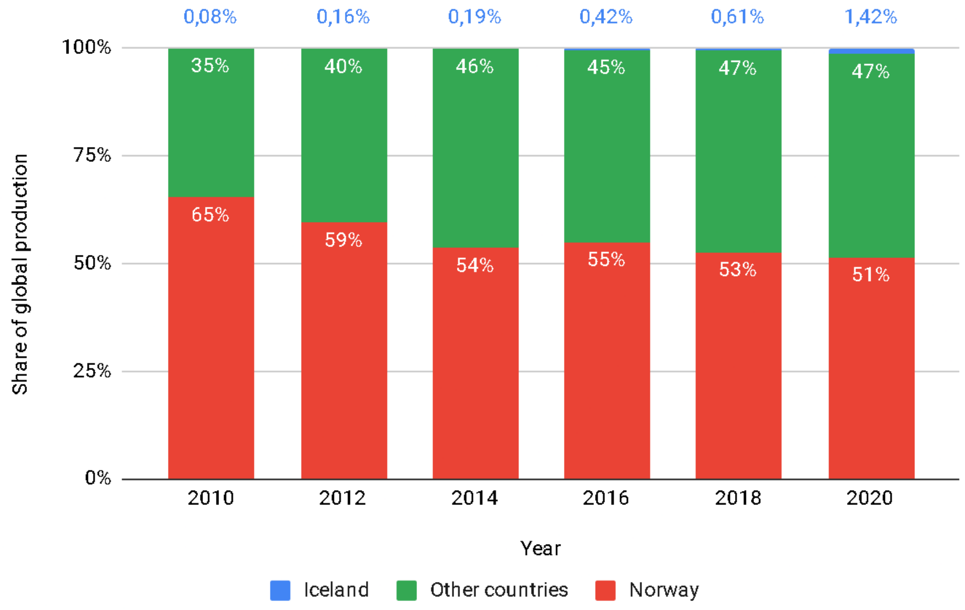

Figure 13 Share of global production every two years from 2010 to 2020. (Source: Norwegian Fisheries Directorate 2020, Norwegian seafood council 2021, SFS 2021 and Statista 2021)

Figure 14, below, illustrates the industries' percentage of total national exports. From this, it apears that the development of Iceland's salmon farming is making an impact on the country's economy. An increase in the share of total exports for Norway can also be seen for the period.

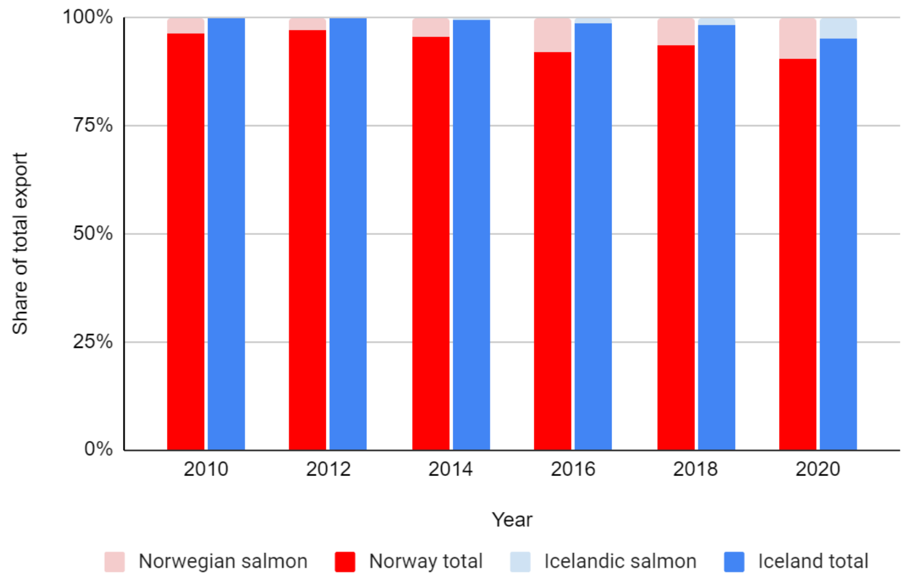

Figure 14 Share of national export.(Source: SSB 2021, Statistics Iceland 2021)

By using the countries' share of salmon export relative to their countries total export and dividing this by the global share of salmon relative to the total share of globally traded goods, we get the *revealed* comparative advantage, as explained in the theory chapter. This is for the same period as the previous figures, and we see that Iceland is believed to have a comparative advantage in the industry between 2016 and 2020, as the threshold for this status is 1.

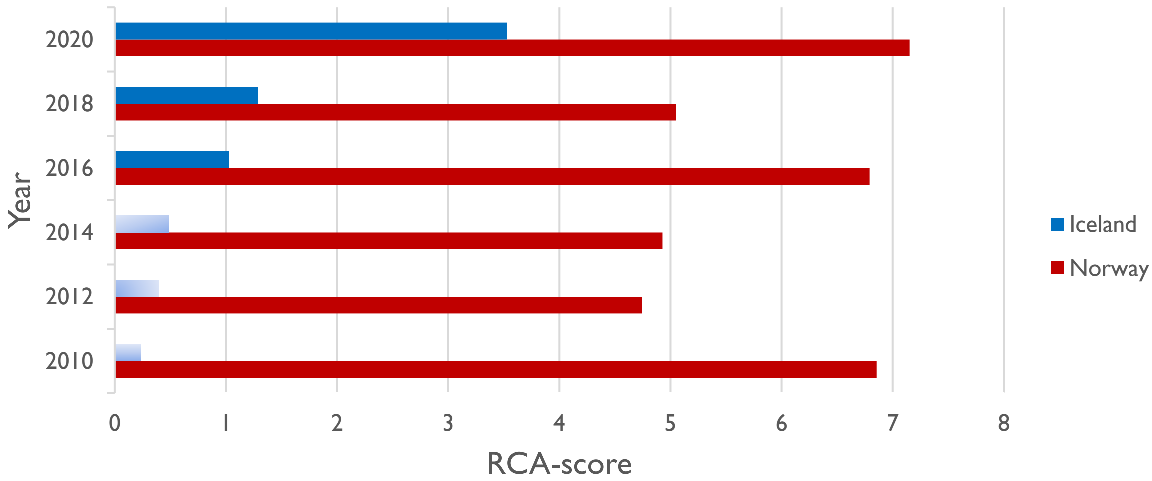

Figure 15 The industries revealed comparative advantage compared to total global trade

The fact that Iceland's salmon farming industry is considered to have comparative advantages despite having less than 2% of the global market share has a lot to do with the country's small economy. However, with a doubling of their production, their RCA score will likely be at the same level as Norway.

6.2 Price achievement, average weight, and production cost

In the figure below, we can compare the average slaughter for three generations. The average slaughter weight differs significantly between the countries, and Iceland has on average a higher weight than Norway. For the 2017 generation, this difference was 1,2 kg. In general, customers pay more for bigger fish, and as the average slaughter weight (HOG) for salmon is higher than in Norway (see figure 16), it is reasonable to assume that Iceland achieves higher prices than Norway. Some salmon farming companies in Iceland claim to get a price premium for their salmon. However, as there have been reported biological issues related to BKD and winter ulcers in the compared period, which can affect the quality distribution, a decision was made to use the annual average market price from NASDAQ when calculating production cost per kg for the Icelandic companies. The same index has been used when analyzing the production costs for the Norwegian segments of the top 5 stock listed companies. However, as seen in figure 16, Iceland exceeds the 5 kg threshold on average, and Iceland is therefore in a higher price category than Norway.

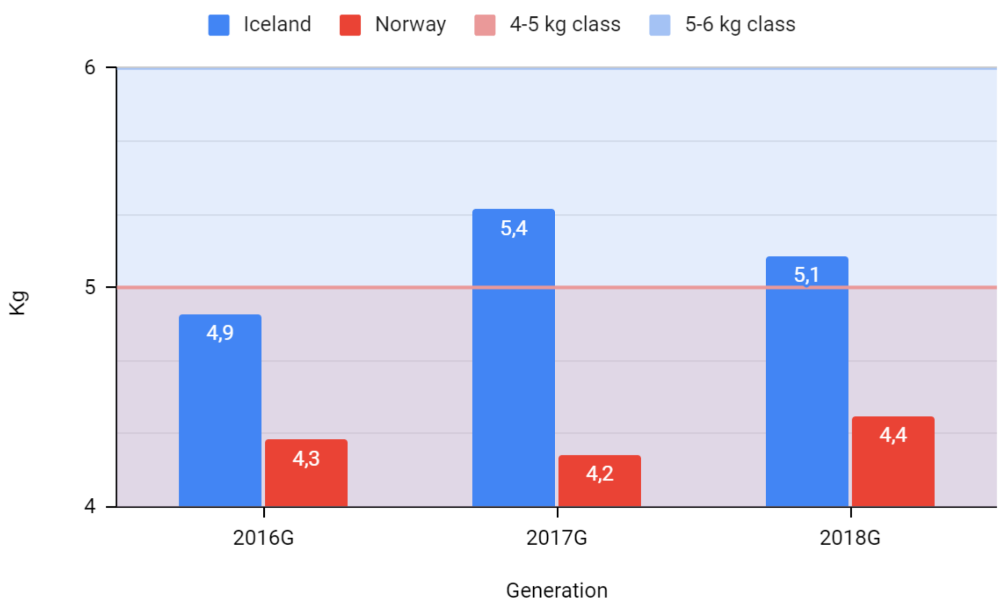

Figure 16 Average gutted slaughter weight by generation for Iceland and Norway. NASDAQ price classes are highlighted by the light red and light blue areas.

Both cost levels and cost development for the 2016-2020 period are significantly different between the two countries. The production costs for the average Norwegian operators are relatively stable between 4 and 4,4 EUR per kg, while the production costs in Iceland have fluctuated between 5,3 and 8,5 EUR per kg, peaking in 2018. On average, Icelandic companies had a 68 percent higher per kg cost annually than the Norwegian operators in this period.

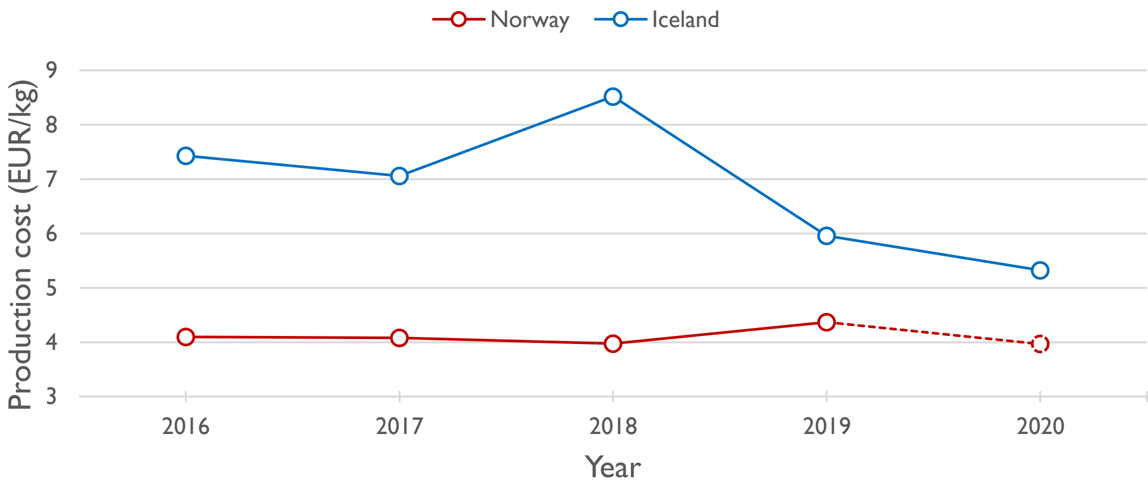

Figure 17 Production cost in EUR per kg gutted salmon for 2018-2018, including harvesting and packing cost. (Source: Norwegian fisheries directorate and company data)

The annual difference between Icelandic operations and the top five stock listed companies in Norway can be compared in the figure below.

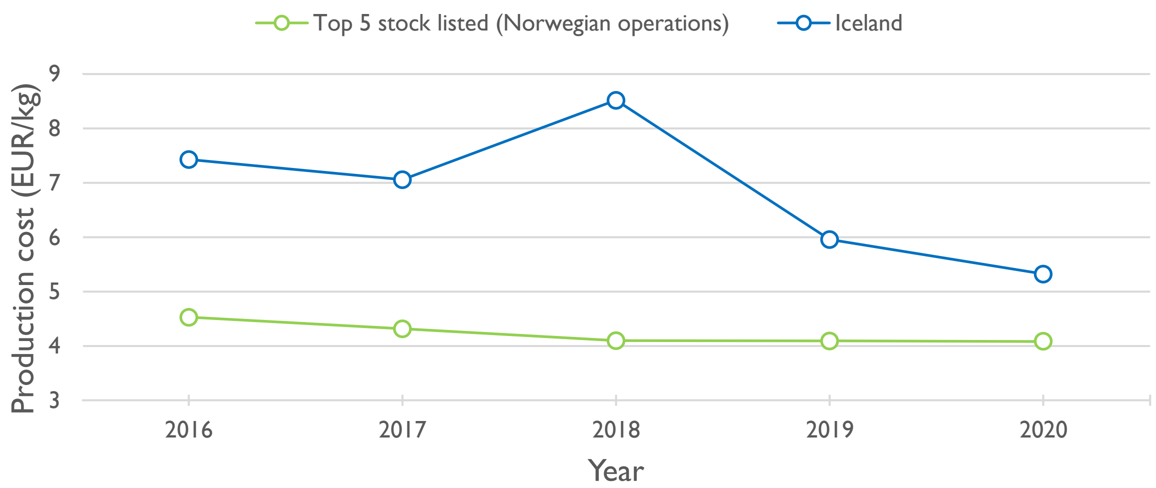

Figure 18: Production cost in EUR per kg gutted salmon for 2016-2020, including harvesting and packing cost. (Source: private company data and public financial statements)

Here we see that the annual difference is slightly less, yet significant, averaging 62 percent higher. For Iceland, the production cost per kg was 5,3 EUR 2020, only 30 percent higher than the Norwegian segment of the top 5 stock listed companies. For all groups, the best year in terms of cost efficiency was 2020. However, the production costs for Icelandic salmon farming companies could have been higher in reality, as the calculation used in this study is based on the difference between operational EBIT/kg and market price; hence, possible price premiums have been excluded. See the method chapter for the justification of this.

The competitive position: status quo

What we have found so far is that Norway has the overall cost advantage over Iceland. The 4-5 kg is the median price category in the whole industry[1], we can say that Norway has price parity, and as Norwegian salmon farmers have a production cost per kg around 20% below this price class, the Norwegian salmon farming industry can be determined as having a competitive advantage position. See figure below.

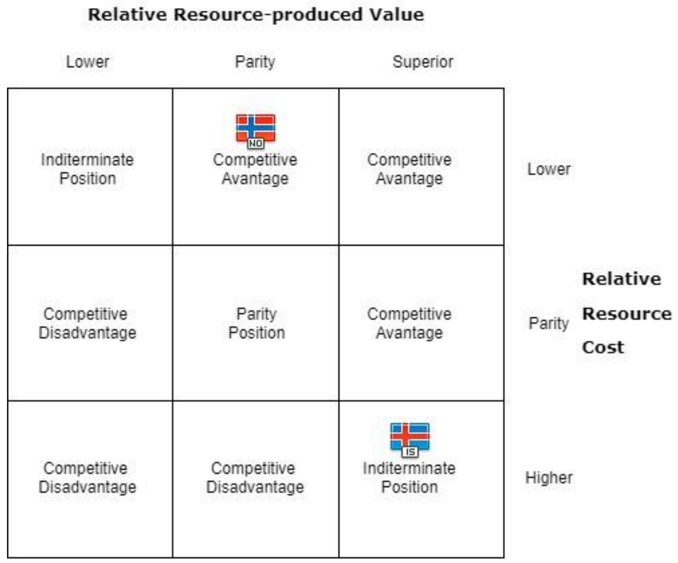

Figure 19 The competitive positions of the Icelandic and Norwegian salmon farming industry in Hunt and Morgan matrix

The companies in Iceland do not have good cost performance for the compared years. The production costs are significantly higher than what Norwegian operators achieve, and even globally compared. Iceland's record low production cost of 5,3 EUR per kg in 2020 is significantly higher than the highest production costs observed among the top 5 countries between 2003 and 2018 (Iversen et al., 2020). According to this study, Scotland had a production cost of 5,93 USD per kg gutted salmon, which equates to 5,02 EUR using the annual average exchange rate for that year.

According to Hunt and Morgan (1995), companies that have to pay more for their inputs will be less competitive if they also achieve the same price as their competitors. In this case, Iceland

[1] https://fishpool.eu/price-information/spot-prices/weekly-details/ (shows that the 4-5 kg has the highest "weight" among the price categories)

gets a higher price for its salmon due to higher average slaughter weight and maybe also due to price premiums is reasonable to place Iceland in the southeast cell in the Hunt and Morgan matrix, the indeterminate competitive position. That means that based on economic performance, we cannot say whether the Icelandic salmon farming industry is in an advantageous or a disadvantageous competitive position.

That we cannot define the competitive position of Iceland does not exclude the possibility of Iceland being a significant and highly efficient salmon producing nation in the future, nor does it exclude the possibility of a third collapse for the industry. According to the RCA score of the countries presented earlier in figure 12, both Iceland and Norway have comparative advantages in the industry. Exploring what these advantages are and how they impact productivity will provide useful information that might explain cost differences, cost structure. First step is to look at the results from the partial productivity analysis.

6.3 Biologic performance

In this section, the biological indicators of smolt yield, production loss, and economical feed efficiency will be analyzed and assessed in conjunction with each other.

6.3.1 Smolt yield

Smolt yield is a biological productivity measure and indicates how much biomass one released smolt yields. As seen in the figure 20, the smolt yield in Norway was generally around 3,5 kg among the 2016-2018 generations, although it had a slight linear increase.

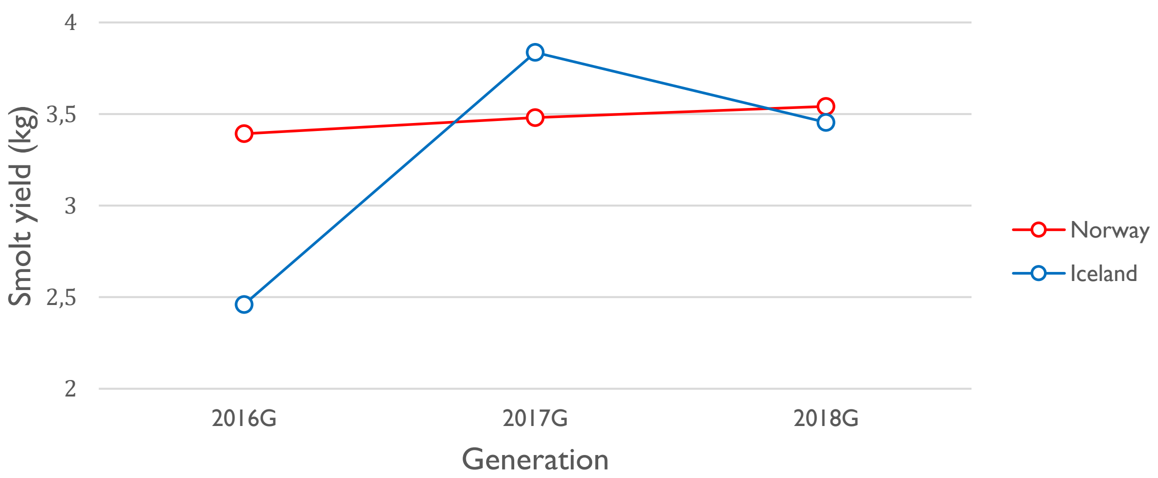

Figure 20 Smolt yield (kg harvested gutted weight/smolts released) by generation (Source: private company data and Iversen et al. (2020))

The smolt yield in Iceland had a more varied development. The 2016 generation was measured at 2,5 kg, almost 30 percent less than what of Norway. On the contrary, the 2017 gen in Iceland reached 3,8 kg in smolt yield, thus, surpassing what was observed in Norway for that generation. The successive generation suffered a ~10 percent decrease, down to 3,5 kg, compared to the previous generation, which demonstrates an insignificant difference in smolt yield between the countries for the 2018 generation.

6.3.2 Loss in production

Loss in production is the percent difference between smolts released and numbers of individuals slaughtered. Production loss comprises mortality, escapees, sample fish, and non-achievers that are stamped out. The results from this analysis can be compared in Figure 21 below.

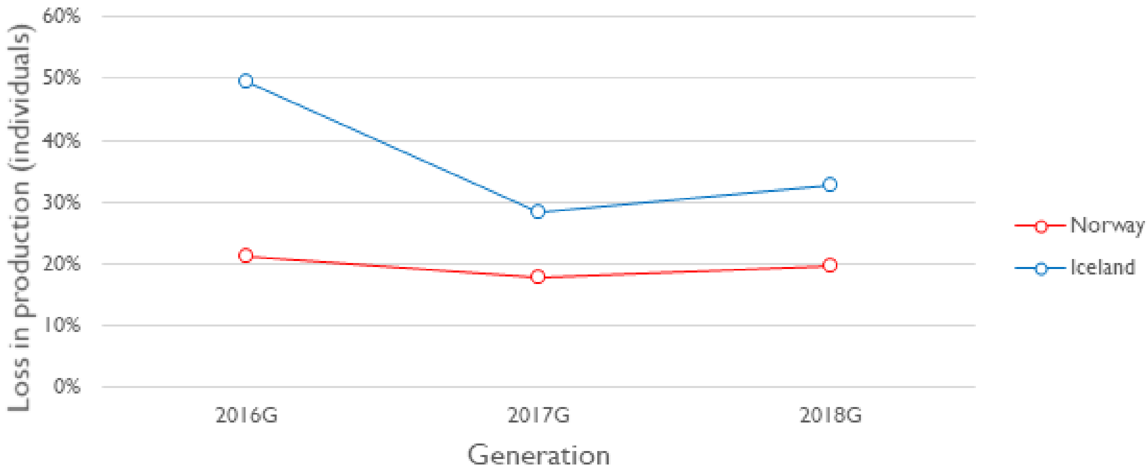

Figure 21 Loss in production (percentage of numbers of individuals not harvested) by generation (Source: private company data and Iversen et al. (2020))

What stands out most in this figure is the 2016 generation of Iceland, measured at 50 percent. This is 2,5 times higher than in Norway, which has had a stable ~20 percent loss in production among the three generations. The two succeeding generations of Iceland perform relatively better with a ~30 percent loss in production, down by ~40 percent. The causes of loss in mortality can be traced to several incidents of BKD (*bacterial kidney disease)* and, or in combination with, cold-related challenges (ilaks.no, 2018; Kyst.no, 2017; RUV, 2020)

6.3.3 Economic feed conversion rate

The economic feed conversion ratio is a measure of total feed and is calculated by dividing slaughtered biomass on the accumulated feed consumption for the whole generation.

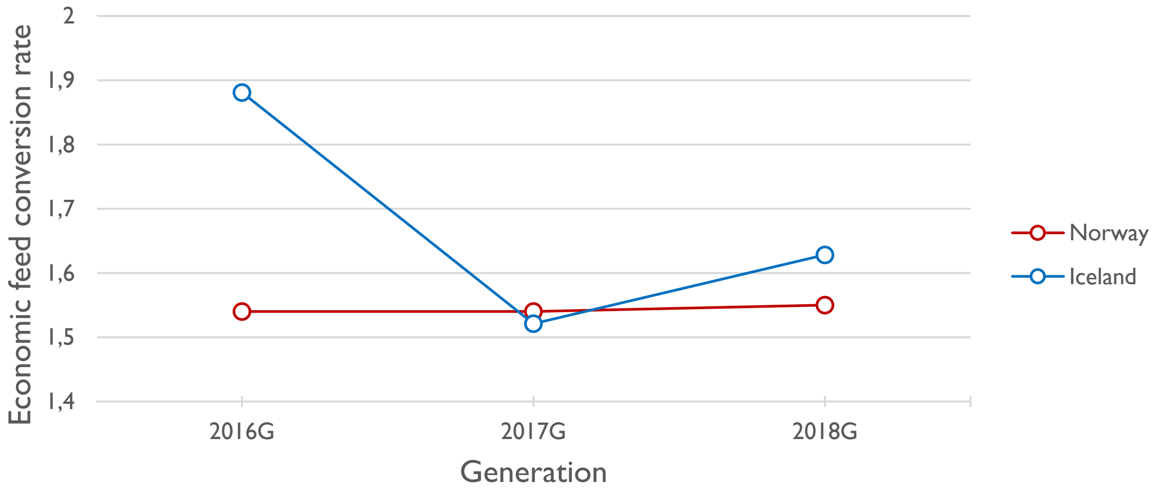

Figure 22 Economic feed conversion ratio (accumulated feed consumption / harvested gutted salmons) by generation. (Source: private company data and Iversen et al. (2020))

Similar to the previous productivity measures, Norway is stable among the generations, and the EFCR for gutted harvested salmon is measured at around 1,54. Corresponding with the other results, Iceland's 2016 generation is also here on a less desirable level than in Norway, ending on 1,88. This equates to a 22 percent higher feed usage than in. On the other hand, the next generations improved significantly and was below the Norwegian average for 17G, and only 5 percent above Norway in feed consumption for 18G.

6.3.4 Discussion

Hypothesis: biological performance of Iceland is not worse than in Norway

On average, all biological performance measures were worse for Iceland compared to Norway for the three generations, and we have to reject the hypothesis.

This is naturally explained by the high and varying loss in production, as both feed factor and smolt yield are affected by this. Smolt yield is also affected by average slaughter weight, but, as we can see in the figure? this is relatively stable while smolt yield covaries with loss in production.

When we compare the countries' relative differences for each generation among the different measures, some interesting distinctions arises that can be useful to determine the overall differences in natural conditions between the countries.

For EFCR, we see that Iceland is relatively competitive in 17G and 18G, with 1 percent lower and 5 percent higher feed consumption than Norway for the respective generations. For 16G, the EFCR is significantly worse, ending at 1,88 - 22 percent higher than Norway.

Table 2 Economic feed conversion rate and percentage difference between the countries.

Generation	Norway	Iceland	Ice-Nor %
16G	1,54	1,88	22 %
17G	1,54	1,52	-1 %
18G	1,55	1,63	5 %

In production loss, however, the differences relatively much higher. Iceland's production loss is 138,56, and 56 percent higher than Norway's, respectively.

Table 3 Production loss and percentage difference between the countries.

Generation	Norway	Iceland	Ice-Nor %
16G	21 %	50 %	138 %
17G	18 %	28 %	56 %
18G	20 %	33 %	65 %

Under the reasonable assumptions that the salmons have similar metabolic properties and weight when released, this relative difference indicates that the weight of lost fish must be smaller in Iceland than in Norway. This is in accordance with Iversen et al. (2015), which confirms that the individual mortality weight in Norwegian aquaculture increases along with the rise in sea lice treatments that are executed more frequently on bigger fish.

When comparing directly for cost impact, we have to take the differences in production cycle into consideration, as the annual financial results account for the accumulated costs of sold goods. Labor costs are, however accounted annually. In Iceland, it takes around 22 months when the smolt is 100g when released (Icefish report), but in Norway, the production time at sea is between 14 and 17 months on average (Iversen et al., 2018). This is due to difference in temperature.

The tables below show the relative differences between one generation in Iceland and the next generation in Norway:

Table 4 The relative differences in EFCR between one generation in Iceland and the next generation in Norway

Country	**16G**	**17G**	**18G**
Norway	1,54	1,54	1,55
Iceland	1,88	1,52	1,63
Diff between Ice and Norway(+1G)	1,22	0,98	

Table 5 The relative differences in production loss between one generation in Iceland and the next generation in Norway

Generation	**16G**	**17G**	**18G**
Norway	21 %	18 %	20 %
Iceland	50 %	28 %	33 %
Diff between Ice and Norway(+1G)	278 %	140 %	

6.4 Labor productivity

Official data on sea site employees in Iceland for 2019 are not available, but are estimated based on the average employee growth in listed companies between 2018 and 2019. Between those two years, the industry's average employment growth was 6 percent. The figure below illustrates the development in labor productivity as measured in kilograms produced per worker. Although the gap is considerable, Iceland's development is showing signs of increased productivity.

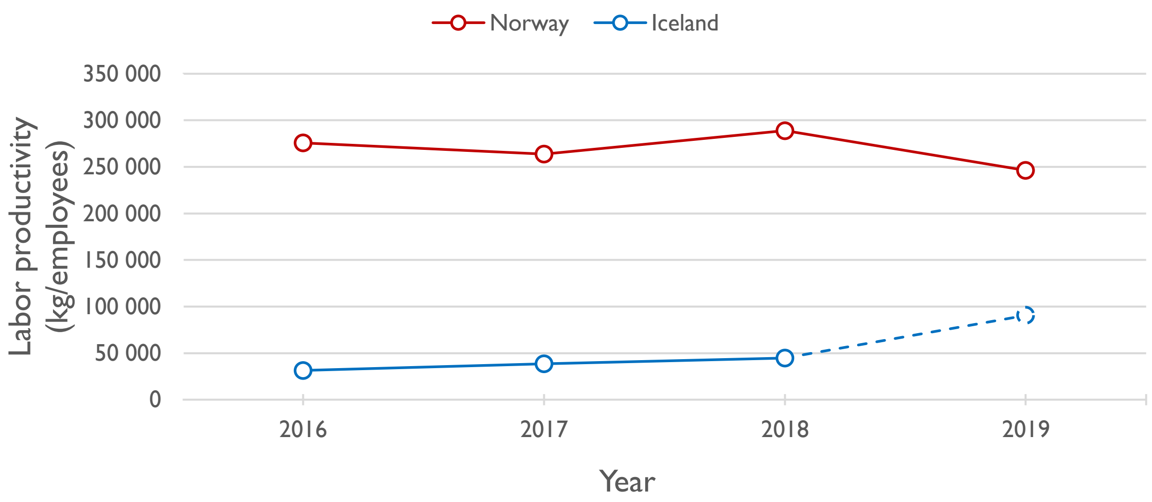

Figure 23 Annual labor productivity (kg per employee) at sea site. (Source: Norwegian Fisheries Directorate and SFS)

When comparing the number of smolts released per worker, the difference is even smaller but still significant.

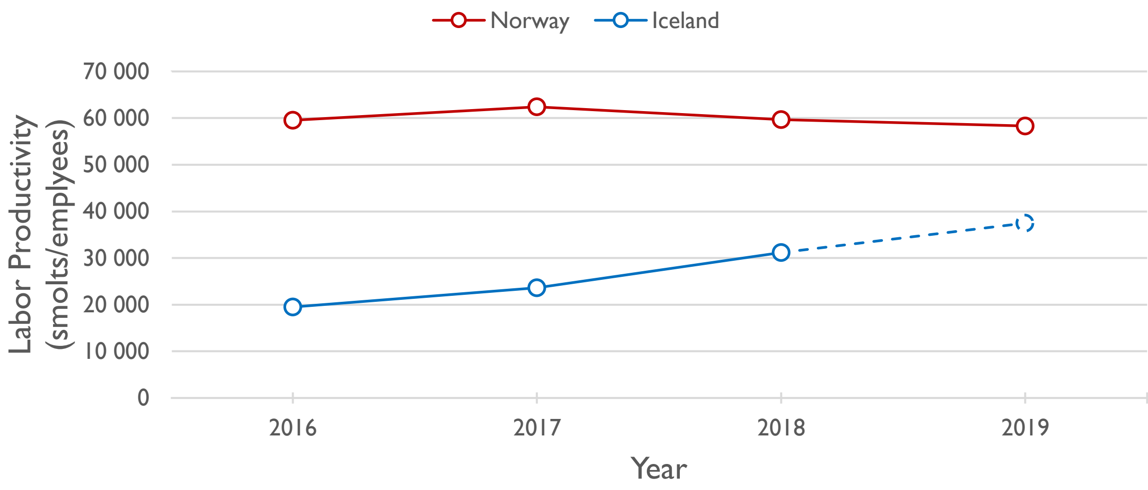

Figure 24 Annual labor productivity (released smolts per employee) at sea site. (Source: Norwegian Fisheries Directorate and SFS)

6.4.1 Discussion

The difference in labor efficiency can, at least partially, be explained by their difference in development rate. Iceland has exponential growth, while Norway relatively little growth. Since it takes more than one year from release to harvest, it makes sense that the annual production per worker is lower, as the number of individuals in production is increasing every year. The Icelandic government has issued more than twice as much MAB than what has been achieved so far, meaning that the companies are building biomass and will continue to release more smolts than the preceding year. This argument is further supported when we compare the relative difference between production per labor and smolts released per worker, as shown in the table below. The production per worker in Iceland in 2018 was only 15 percent of Norway, while the smolts released per worker was 52 percen of what it was in Norway for the same year.

Table 6 Production per worker in kg and percent vs. smolts released per worker in numbers and percent. Source: Norwegian Fisheries Directorate and SFS

Year	Production per worker			Smolts released per worker		
	Norway	Iceland	%	Norway	Iceland	%
2016	275 669 kg	31 410 kg	11 %	59 541	19 505	33 %
2017	263 784 kg	38 501 kg	15 %	62 403	23 598	38 %
2018	288 960 kg	44 754 kg	15 %	59 677	31 158	52 %
2019	*246 251 kg*	*90 491 kg*	*37 %*	*58 312*	*37 482*	*64 %*

Additionally, the contrasting labor productivity between the countries can be ascribed to the production time in the sea, along with limited locations for optimal rotation. In Iceland, it takes around 22 months when the smolt is 100g when released (Icefish report), but in Norway, the production time at sea is between 14 and 17 months on average (Iversen et al., 2018). This can, in turn, be ascribed to the temperature differences.

6.5 The cost category perspective

In this section, an attempt is made to apply the newly acquired knowledge to understand the cost drivers. As these data are available, this will be done from a cost category standpoint by benchmarking against Norway. The hope is that this will provide a more accurate picture of the countries' potential competitiveness and, in turn, whether it changes the initial perception of the desirability of the national environments being compared.

6.5.1 "What-if" Analysis

The ability of the revealed difference in labor productivity and biological productivity to account for differences in production costs will be investigated in this section. This will be done by multiplying the smolt cost per kg, feed cost per kg, and labor cost per kg for Norway with the relative difference in production loss, EFCR, and labor productivity. By comparing countries with comparable unit prices for smolt, feed, and labor, we seek to isolate the effect of labor efficiency and biologic performance on production costs. Furthermore, two sets of scenarios are explored: one for Iceland's worst-performing generation (16G), and another for the best-performing generation (17G).

Given that the majority of released smolts in Norway are harvested the following year, while the majority in Iceland are harvested two years later, the relative difference between one generation in Iceland and the following generation in Norway is used as a multiplier for feed and smolt costs, for example, 16G of Iceland and 17G of Norway. Additionally, we use the difference in annual labor efficiency as a multiplier for labor cost.

If all held equal, including salaries, feed prices, and smolt prices, we could see a total cost increase of 53 percent when simulating for the difference in 16G and 6,46 times higher labor productivity that year. In this case, the table below suggest that the cost that comes with low labor efficiency can explain 40 percent points of the 115 percent production cost difference between the countries that year. The 178 percent higher production loss is only counting for 5 percent points, and the 22 percent higher feed use only counts for 8 percent points.

Table 7 Ceteris paribus comparison of the impact production loss, EFCR for 16G and labor productivity multiple in 2018 would have on Norways 2018 production costs per kg. (Source: Norwegian Fisheries Directorate).

Cost category	2018 (NOK)	Multiplier	Revealed diff.	Scenario 1.1	Scenario 1.2	Scenario 1.3
Smolt	3,87	2,78		10,77	10,77	10,77
Feed	15,91	1,22		15,91	19,44	19,44
Labor	3,15	6,46		3,15	3,15	20,31
Deductions	2,47			2,47	2,47	2,47
Misc.	8,45			8,45	8,45	8,45
Harvest and slaughter	4,26			4,26	4,26	4,26
Total	38,11			45,01	48,53	65,69
% higher			115 %	5 %	13 %	53 %

When we compare the costs of Iceland's best-performing generation (17G) harvested in 2019, we see that the total difference, assuming all other factors remain constant, is 18 percent points of the 36 percent revealed cost difference that year. Iceland's 2 percent reduction in feed consumption is negligible, but the 40 percent increase in production loss would amount to 4 percent points in this scenario. The labor efficiency difference would in this case account for 14 percent points.

Table 8 Ceteris paribus comparison of the impact production loss, EFCR for 17G and labor productivity multiple in 2019 would have on Norway's 2019 production costs per kg.

Cost category per kg	2019 (NOK)	Multiplier	Revealed diff.	Scenario 2.1	Scenario 2.2	Scenario 2.3
Smolt	4,62	1,40		6,46	6,46	6,46
Feed	17,59	0,98		17,59	17,26	17,26
Labor	3,59	2,72		3,59	3,59	9,76
Deductions	2,90			2,90	2,90	2,90
Misc.	10,17			10,17	10,17	10,17
Harvest and slaughter	4,18			4,18	4,18	4,18
Total	43,04			44,88	44,55	50,73
% higher			36 %	4 %	4 %	18 %

At first glance, it appears that the loss in production has impacted the labor productivity, but when looking at smolt yield, that is seemingly just true for 16G and 2018, with the 2017 generation of Iceland yielding more biomass per released smolt. With equal unit prices for smolt and feed this year and other cost groups remaining constant, the difference in production costs would be only 4 percent, despite the 40 percent higher mortality.

This analysis suggests, among other things, that the biological performance differences are unproportionate to the actual cost difference and that high losses most likely do not constitute a make it or break it factor for Icelands future in the Industry.

While the cost composition in Iceland is unknown in reality, this analysis provides some insight into how it might look in the future. However, one cost constant that is reasonable to assume is true is labor cost because the average wage in each country is nearly identical (SSB 2021, Statistics Iceland 2021). The labor cost of 20 NOK in 2018 and 10 NOK per kg in 2019 would represent a labor cost proportion of around 25 percent and 17 percent, respectively. Although this has not been examined in detail and weighted for production size; we can observe similar labor cost ratios in the financial statements of Icelandic salmon farming companies.

Among the performance measures calculated in this study so far, we see (in the figure below) that labor productivity is where the shoe pinches the most, as it is the area with the greatest gap.

Figure 25 Efficiency categories. Iceland benchmarked against Norway (+1G)

6.6 Discussion

Having identified one definite cost advantage Norway has over Iceland, namely labor costs, we will review the other cost categories.

It is likely to believe that the unit prices on feed are higher on Iceland due to transport costs, as the informants have implied. And, because Iceland is a younger industry, it is possible that significant investments in production equipment have been made recently, and as conventional accounting principles dictate that one deducts more for purchased goods in the beginning, it is reasonable to assume that Icelandic salmon farmers have higher deduction costs. This could also apply to the unit price of smolts as well, but there have been significant investments new smolt facilities in Norway as well (Iversen et al. 2018). On the other hand, access to geothermal water reduces the amount of energy required to regulate the water temperature at smolt sites, indicating that the unit prices for smolt in Iceland might actually be lower.

For slaughter and harvesting costs, it is not evident that Iceland necessarily suffers any cost disadvantages. Proximity to a global leading and highly competitive supplier of well boat services is likely to be more favorable for the Norwegian salmon farmers. The slaughtering part of this segment, on the other hand, is more open due to Iceland's extensive experience in fish processing.

It is unknown whether Iceland should be at the same level of "various costs," which account for well over 20 percent of the Norwegian cost structure. Norway's salmon farmers face significant costs associated with delicing operations (Iversen et al. 2019), which are performed seldomly in Iceland. According to the veterinarian report of G. Jonson (2020), there was only one delicing event in Iceland the same year. On the other hand, mortality incidents will increase "various costs" as service vessels, diving operations, and ensilage services outsourced from most salmon farming companies, also in Norway. Furthermore, because these services are limited in the domestic market, their unit costs will be higher, as is the case with well boats.

One cost advantage of Norway is that they have higher labor productivity in kg produced per employee compared to Iceland. Given the productivity lag and the fact that annual growth in smolts is 30 percent while annual growth in employees is 6 percent, we have identified a significant cost group that will almost certainly decrease for Iceland. In the results, we find that the difference in labor efficiency counts for around 40 percent of the cost differences when the biological parameters are relatively similar. Due to temperature differences, it is not immediately obvious how Iceland could achieve Norway's level of labor productivity. If generational smolt yields are similar but production time differs by as much as 37.5 percent, as the difference between 16 and 22 months does, this has an indirect effect on the mortality rate, at least to some extent. Iceland must reduce production losses until smolt yield increases by the same percentage. If the MAB is maximized now, at average weights of 5+ kg, the possibility of increasing smolt yield by 37,5 percent is limited, as reduced losses will result in the MAB being reached sooner and at a lower average weight, unless smolt release is also reduced. In other words, obtaining Norway's level of annual smolt yield will be difficult. Given that mortality has been linked to cold sea temperatures in Iceland, one could argue that one of the fundamental causes of economic performance disparity is temperature. This is not an absolute requirement for Iceland to succeed as a salmon farming nation, but it illustrates that temperature production time in the sea is a vital impact factor.

However, the advantage of being located on a volcanic island is that temperature regulation is almost completely free via geothermal water in smolt production. Iceland may be able to circumvent the production time constraint at sea by releasing larger smolts. One can say that this option is a *strategical substitute* that is available (Barney 1991).

Another comparative advantage Norway has over Iceland is the presence of critical suppliers in feed, equipment, and services. This disadvantage is likely to cause extra transport costs and other inconveniences. This may represent a sustained competitive advantage for Norway, but industries are mobile, and a viable home market for these supplies could theoretically emerge in Iceland. Furthermore, the companies have the opportunity to vertically integrate, as has been done successfully in Bakkafrost on the Faroe Islands, but it is most likely that Iceland will continue to be at a cost disadvantage in this.

Though the productivity analysis can not observe that research institutions, technological development, and industry know-how in public management are sources of difference, these could be important for the future. Additionally, financing is critical for mitigating negative and fluctuating consequences; biological and price uncertainty can affect productivity (Sikveland & Zhang,2020); and Iceland's higher tax burden than Norway (see tax comparison in Appendix C) may impose a future disadvantage on Iceland by hindering financial flexibility.

Limitations:

As with other studies, the findings in this study must be interpreted in light of some limitations. To begin, the case study design nature and its limitations to establish causality. Second, the scarcity of research in Icelandic aquaculture and the representativeness of the expert panel. Finally, the quantitative data cover a short period, and that some estimates of data points have been made at various stages of the analysis.

However, the subject's size and research objectives, compared to the time available, necessitated narrowing the variables to investigate. The case study design allows for connecting between the units of analysis gain a better understanding, which is advantageous due to the scarcity of literature on Icelandic slamon farming. The bioeconomic parameters presented in this study are unique and contribute to new knowledge about the Icelandic salmon farming industry.

7 Conclusion

This thesis aimed to assess the prospects for success of the Icelandic salmon farming industry. Specifically, it aimed to assess the industry´s current competitive situation, its potential development, and influenced by Porter's "Diamond" model (1990); what country-specific differences are of most interest. A unique data set from Icelandicsalmon farming companies were collected, biological data from three generations and operational ebit in EUR per kg. On the basis of a systematic and in-depth analysis of biological performance and labor efficiency, as well as the industry's context, it is possible to conclude that the prospects for Iceland's salmon farming industry appear to be promising.

The findings that support the beliefs in industry success are not shocking, nor are they a threat to Norway's competitive position, which serves as the benchmark in this study. The criterion for a viable future in salmon farming is not about being the best but also not being the worst performer. In comparison to Norway, Iceland's costs per kg of salmon produced varied but were found to be significantly higher. The fact that Iceland has higher prices due to higher slaughter weight and possible premium prices over the comparison period made it more challenging to decide exactly what Iceland's *current* competitive position is, as in the "indeterminate" position in Hunt and Morgan (1995).

The explanatory value of country-specific advantages on economic performance cannot be determined precisely in this case because the underlying causes of labor inefficiency, which is measured to account for 40 percent of the total cost performance difference, are highly interrelated to each other. The analysis reveals that exponential growth rate and lag in production, as well as temperature and mortality, are currently regarded as factors influencing labor efficiency in Iceland. When the development has returned to normal, the "ultimate" factor in the national environment that influences labor efficiency is temperature, as it determines production time at sea and has shown to affect mortality. On the other hand, Iceland's performance has demonstrated that despite biological issues, the country maintains a smolt yield and economic feed efficiency rate comparable to Norway for two of three generations. Though not surprising, the data show with high certainty that mortality occurs earlier in Iceland than in Norway. Another aspect of the national environment that is highlighted as a likely source of disadvantage for Iceland is the absence of globally competitive suppliers, which logically results in increased transportation costs and other inconveniences.

The overall trend, along with the opportunities to circumvent the current cost disadvantages is what makes Iceland a feasible salmon farming nation for the future.

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Appendix A – Norwegian Legislation on Aquaculture

In Norway aquaculture is defined as "production of aquactic organisms". Aquatic organisms are to be interpreted as animals and plants that live in water, and production is considered "any activity that aims to impact the weight, size, amount, function or quality of living aquactic organisms" cf Aquaculture Act of 17th of June 2006 no. 79 section 2. And the objective of the law is to "promote the industry's profitability and competitiveness within the frames of a sustainable development, and to contribute to value creation on the coast" cf section 1.

The Aquaculture Act is the main legislative source that regulates salmon farming and other aquaculture activities, and the Ministry of Trade and Fisheries (MIF) is the principal authority for this Act. Like other industry activities, aspects of the salmon farming industry touch various societal and environmental spheres, such as food safety, animal welfare, spatial planning, infrastructure, pollution, etc[1]

The sectorial government responsible for these laws are other Ministries, underlying government agencies, and local authorities. These agencies have legal competency to perform delegated functions, delegate these tasks, and/or to impose detailed regulations through the power of the laws mentioned. For a full overview of the administrative agencies and its respective regulations, see the below figure

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[1] Act of 24 November 2000 no. 82 relating to river systems and groundwater [Water Resources Act] , Act of 21st of June 2019 no. 70 relating to harbors and fairways [The Harbour Act], Act of 27 june 2008 no. 71 relating to Planning and the Processing of Building Applications [Planning and Building Act], Act of 19 June 2009 no. 100 relating to the management of biological, geological and landscape diversity [Nature Diversity Act] , Act of 13 March 1981 nr. 6 Concerning Protection Against Pollution and Concerning Waste [Pollution Control Act], Animal Welfare Act of 19 June 2009 no. 97, Act of 15 June 2001 No. 75 relating to veterinarians and other animal health personell, Act of 19 December 2003 No. 124 relating to food production and food safety etc. [Food Act]
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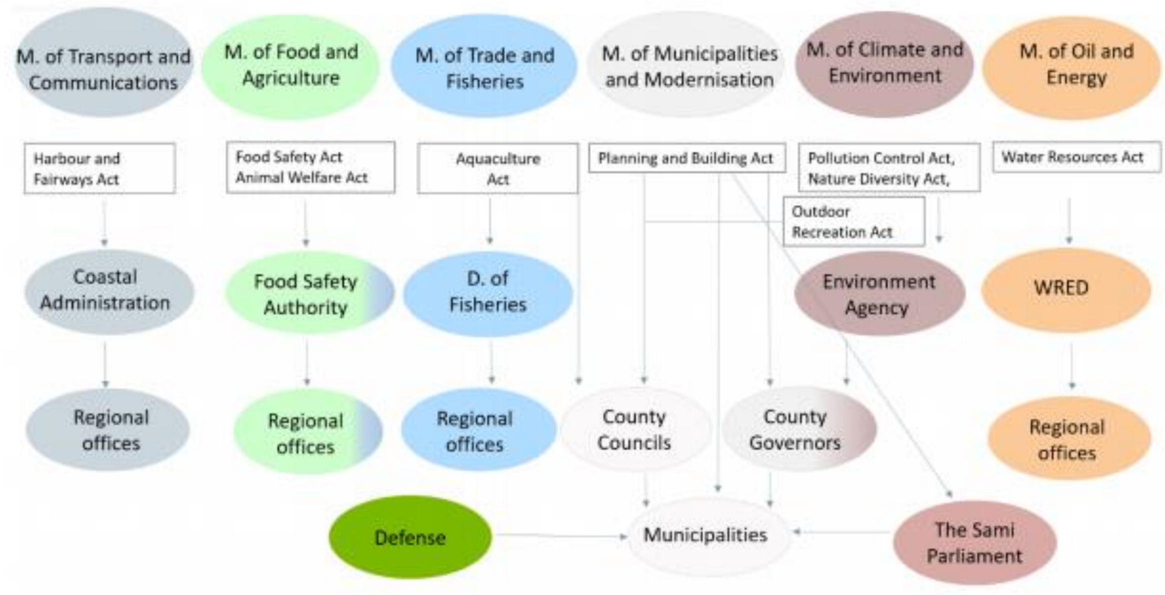

Figure 1 Overview of sector authorithies and legislation. Adapted from Solås et al. (2020)

The production limitations and license process under the Norwegian legal framework:

Section 4 paragraph 2 in the Norwegian Aquaculture act specifies that "No one can do aquaculture without being registered as the owner of the aquaculture license (...)"

Further, one can deduct from the legislation section 5 that an aquaculture license is a right to produce certain species, and this production is bound to a prescribed geographical area (locality or site).

The main production limitation for a license is the maximum allowed biomass (MAB). This means that the biomass at one site never can at any time exceed this value. A standard license for the production of salmon, trout, and seatrout is limited to 780 tons for all counties except for Troms, where the MAB limit is 945 tons[1] . This exemption was intended to compensate for the assumed lower growth conditions in the North.

Normally, a locality has several licenses tied to it, and those licenses are also usually tied to other localities. The reason for this can be linked to the objectives of the law, which is to "promote the industry's profitability and competitiveness within the frames of a sustainable development" cf. section 2. A part of the frames of "sustainable development" is that producers are under obligation to let the site lie fallow for at least two months after each production cycle.[2] Allowing the companies to move the production immediately to another site while the marine environment gets naturally cleansed for diseases and soiling from feed and fish feces, is an example of regulation that harmonize the objectives of environmental sustainability and industry profitavbility.

The question is then, what criteria need to be in place to be issued an operating license?

According to sections 4 and 6 in the Aquaculture Act, The Ministry can give permits to aquaculture activity upon application, conditioned that the applicants fulfill specific criteria pursuant to this act. Instructions on the process and criteria for issuing licenses for salmon, trout and rainbow trout permit aquaculture activity to be specified further in FOR-2004-12-22-1798 (Salmon License Regulation), hereafter SLR. This regulation is empowered by the various sections in the Aquaculture Act (e.g. section 7) that says the Ministry can specify further rules and instructions without parliament deliberation. As long as it does not violate any of the provisions listed in other legislation, the rules specified in SLR are the binding legal source cf. lex superior.

From section 29, the first paragraph follows that *"a locality cannot be utilized for aquaculture unless a "clearance" of location is present. Location-clearance must be attached to one or several particular licenses or a permit commitment."*

[1] FOR-2004-12-22-1798 (Regulation on issuance of salmon licences) section 15, and FOR-2015-06-17-817 (Regulation on increase in MAB) section 5

[2] FOR-2008-06-17-822 (Regulation on aquaculture operation) section 40

Some essential notions in understanding the concept and process of license issuance can be derived from this. Firstly, when talking about license issuance, we are, in reality, speaking of two sets of licenses; (1) a licensing promise and (2) an operating license. Secondly, issuing an operation license is to clear or approve the location and attach it to a license promise or an already existing license.

The authority to issue salmon, trout, and rainbow trout license is delegated to the relevant County Municipality (hereafter CM), cf SLR section 5. However, the notion that the CM has the executive authority to issue aquaculture licenses is a truth with modifications.

Firstly because a license promise, which is a precondition for applying for operational license, is issued by the Ministry cf section 14.

Furthermore, according to section 30, the application processing must be based on approval from sectorial agencies according to their respective legislation. This includes the Food Act and the Act on Animal Welfare (Norwegian Food Safety Authority), the Pollution Act and the Nature Diversity Act (State Gouverneur), The Harbour Act (The Coastal Administration), The Water Resource Act (The Norwegian Water Resource and Energy Directorate). The latter approval is only relevant for land-based activities that need freshwater supply.

The state governor gives its approval based on the aspects regarding nature conservation and issues related to recreational interests, the Coastal Administration gives approval based on the proximity to sea lane and already existing installations in the waters, and The Directorate of Fisheries (DOF) is the relevant authority that makes a statement regarding fisheries interests in the applied area. The Food Safety Authority is supposed to grant permission based on food security and animal welfare. These criteria are embodied in FOR-2008-06-17-823 (Regulation on the establishment of Aquaculture sites), and section 7 in this regulation clarifies that disease risk and proximity to other existing fish farms are central criteria.

Section 30, litra d, also states that the location cannot be contrary to existing area plans according to the Planning and Building Act or existing precautionary measures in the area. Although the local authorities (municipalities) are not listed explicitly as governing authority in any of the provisions in the Aquaculture act or SLR, they are included in the permission process since they are the Planning and Building authority that plan and designate the activities for their terrestrial and sea areas within one nautical mile from the coastline.[1] It is preconditioned that the municipality has allocated a designated area for aquaculture purposes based on the Planning and Building Act rules in the same area as it is applied for.

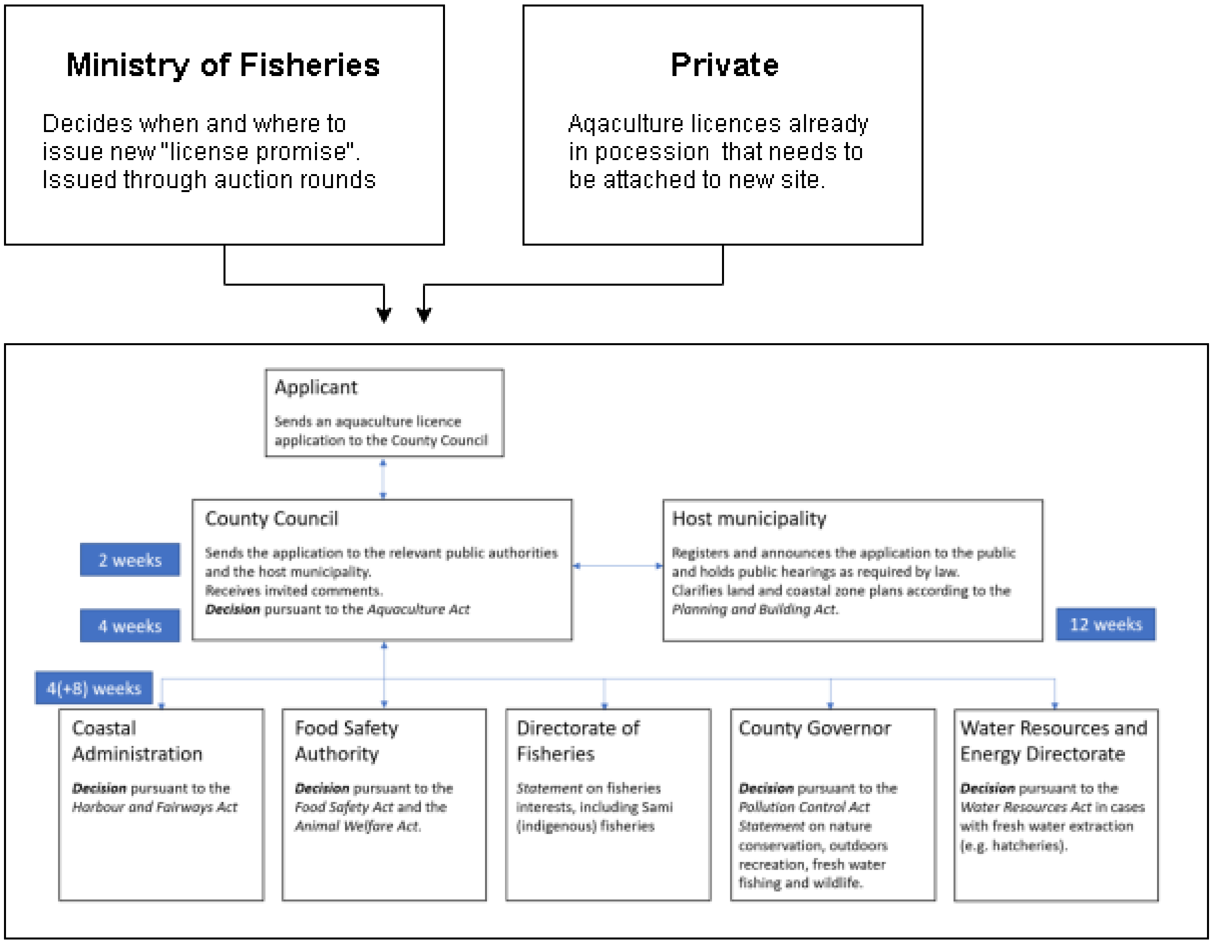

Figure 2 Illustration of aquaculture licensing process in Norway. Modified based on Solås et al.(2020).

In reality, one can say that all the mentioned sector authorities, together with the municipalities, has "veto right" when it comes to clearing the location which is applied for. If any of them are negative to the application, the CM does not have the power to clear the locality and attach it to the existing or promised license. On the other hand, if all sector authorities and the municipality are positive to the application, CM has the authority to decide, based on an overall assessment, to grant aquaculture license. In all cases, the CM is the coordinative organ

[1] See note 3 in FOR-2010-05-18-708 on process of aquaculture applications.

responsible for distributing the application to the other agencies and collecting their decisions within the timeframe specified in FOR-2010-05-18-708, as illustrated in Figure 6.

Limitation to growth

As previously mentioned, SLR section 14, declares that it is up to the Ministery to decide when and whether to issue new licenses. Today, this decision is bound by the so-called traffic light system, regulated in FOR-2017-01-16-61 (Production Area Regulation), hereafter PAR. This regulation was developed as a reaction to the increasing problem of the industries' alleged environmental impact, halting the political will to issue new licenses and production growth since 2012. By dividing the country into 13 production zones, the regulation aims to control the production based on an evaluation of the aggregate environmental impact that has been monitored and reported within each production zone.

Fees and taxation

Companies in Norway are, in general, subject to corporate tax, which is 22 percent. Furthermore, companies are obliged to pay a social tax on their employees' payrolls between 0 and 14.1 percent, depending on the municipality location of the company.

Aquaculture specific fees are the export fee[1], and from 2021, a special fee on production of salmon and salmonoids has been imposed cf FOR-2000-12-13-1253, chap. 5552 post 70. The export fee is set to 0.6 percent of the FOB value of the exported salmon and is used to fund the Norwegian Seafood Council and the Seafood Industries Research fund; the export fee can be seen as a marketing and research fee.

In NOU 2019: 18, a thorough inquiry on aquaculture taxation conducted by an expert panel selected by the Ministry of Finance, it was recommended that the government imposed a tax on profit margins due to the recent years of super profit in the industry. There were not enough mandates in parliament to support this solution, so instead, a production fee of 0.4 NOK per kg produced salmon was introduced.

[1] FOR-2000-12-13-1253

Appendix B – Icelandic Legislation on Aquaculture

For Iceland, the primary legislation is the Act on fish farming no.71/2008, which comprises "farming of marine fish and marine resources in Icelandic waters" cf. section 2. Marine fish and marine resources are defined as respectively; Salmon, trout, char, rainbow trout, eel, and other farmed fish; and fish and marine animals, as well as marine vegetation, which are utilized or may be utilized in the Icelandic fishing zone, the Icelandic continental shelf or on land", cf section 3 item 39 and 25. "Fish farming" is in section 3, item 8 signified as "Any action that can be expected to create or increase fish in fishing waters or the sea." The Icelandic aquaculture law scope seems to be more species-specific but less precise regarding the actions that define fish farming.

Like Norway, the aquaculture activity on Iceland touches many other legal domains and is therefore bound by the legislation presented in Solås et al.(2020)[1]

The principal authoritative agencies governed by these laws are essentially the Ministry of Industry and Innovation, the Ministry of Environment and Natural Resources, and the Ministry of Transport and Local Government. A more explicit representation of the sectorial government/law - relations are depicted in figure 5.

[1]): Act on Health and Pollution Control no. 7/1998 and related regulation no. 941/2002; Act on protection against fish diseases no 60/2006 and related regulation no. 300/2018; Act on handling, processing, and distribution of seafood products no. 55/1998; Act on the organization of ocean and coastal areas no. 88/2018; Act on environmental Impact Assessments no. 106/2000, regulations no. 660/2015 and no. 713/2015 about assessing environmental impacts; Act on hygiene and pollution control no. 89/2018; and Act about the Appellate Committee on Environment and Natural Resources no. 130/2011.

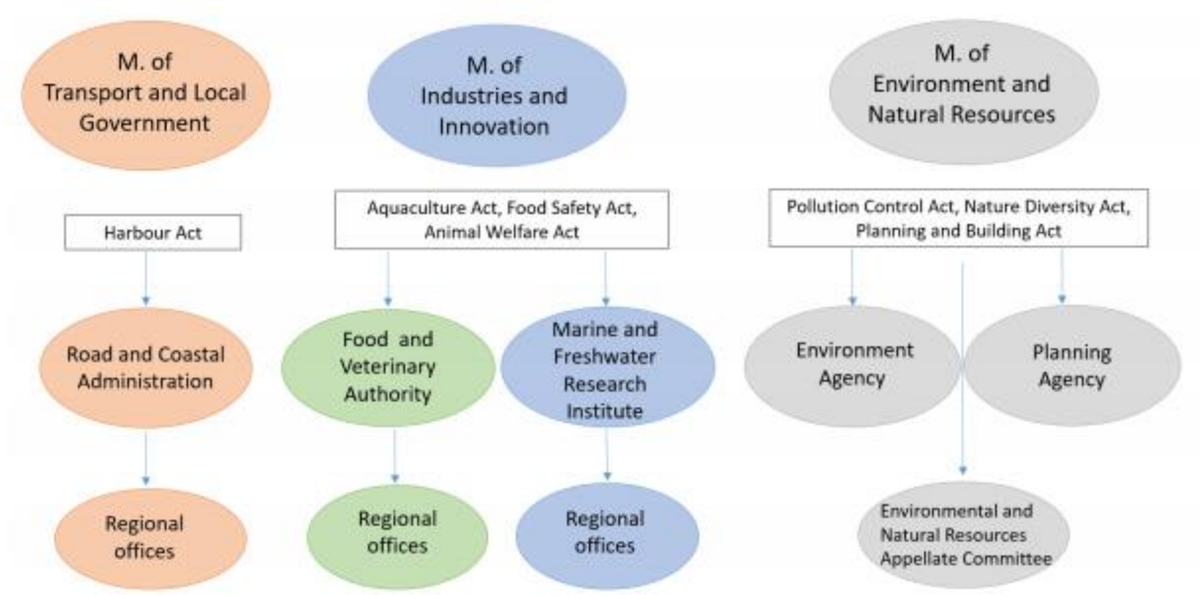

Figure 3 Overview of sector authorities and related legislation for aquaculture in Iceland. Adapted from Solås et al.(2020)

The production limitations and license process under Iceland's legal framework:

License for salmon farming activity is also required on Iceland, cf Act on fish farming no.71/2008 article 4 b which also states that this requires an operating license from the food and veterinary authority (MAST) and an environmental license from the Environmental Agency. Such a license is granted for 16 years cf. section 10, and is usually tied to one or more locations (Interviewee A, personal communication, April 9, 2021).

Before applying for an operating license, an opinion from the Planning Agency or the relevant local government regarding whether the project is subject to the agency's environmental assessment or not must be in place cf Art. 4 b, paragraph 2. It follows from the same paragraph the Food and Veterinary Agency is responsible for sending the application to the Environmental Agency and that the applications will be assessed simultaneously within four weeks.

Furthermore, in Art. 4 a, it follows that the Ministry decides when and to whom aquaculture areas shall be allocated. This is further bounded by the work of the Marine Research Institute on Iceland (MRI), which is responsible for dividing fjords and ocean into aquaculture areas and their respective maximum allowable biomass, and does so based on their assessment of the organic and genetic carrying capacity in the production area. Before division and subdivisions of production areas, MRI must collect statements from the central or local planning agency and the environmental agency.

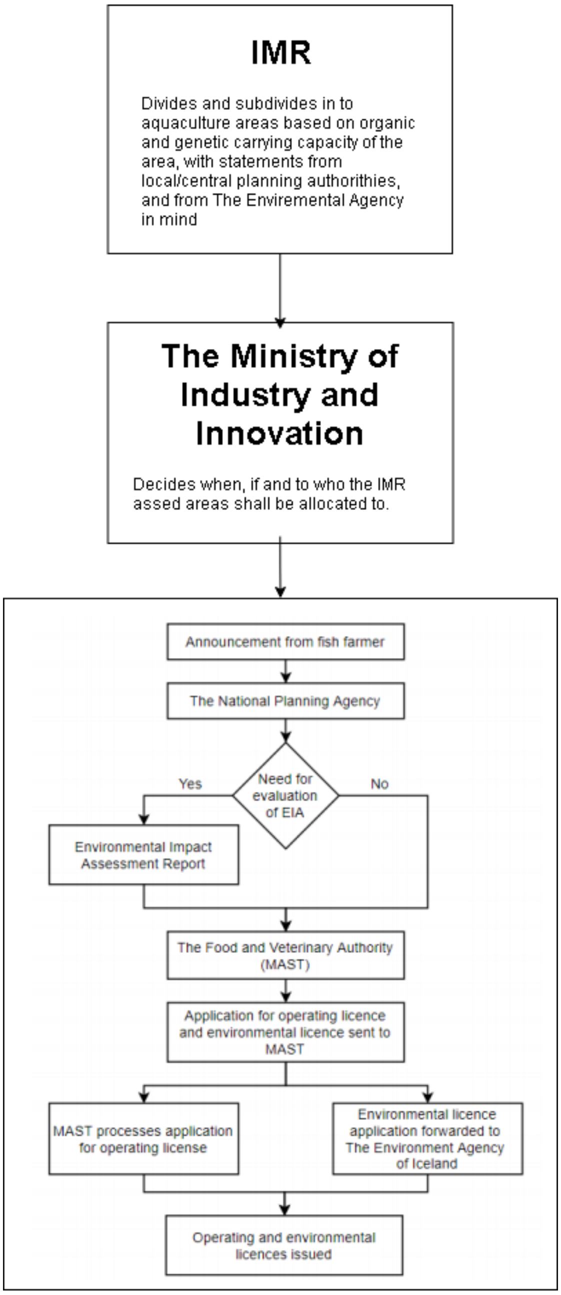

Figure 4 licencing process on Iceland. Modified from Solås et al.(2020)

By looking at the whole system, from zoning to license application process, one can say that each of the involved sector authorities has a "veto right" in affecting the outcome of issuing new licenses in Icelandic Waters.

Limitations to growth

The limitations to growth on Iceland are majorly affected by the biological and genetic carrying capacity assessed by MRI, and the political will cf. the Ministry's authority to decide when and if an area, cleared by MRI, shall be allotted. The aggregate MAB of all fertile salmon licenses issued currently sums to 87 700 tons, while biological carrying capacity on Iceland is 127 000 tons, and the result of the genetic risk assessment has concluded on the maximum threshold of 100 000 tons of farmed fertile salmon for not affecting the wild salmon (MAST). In other words, there is the excess capacity to issue more licenses at this point.

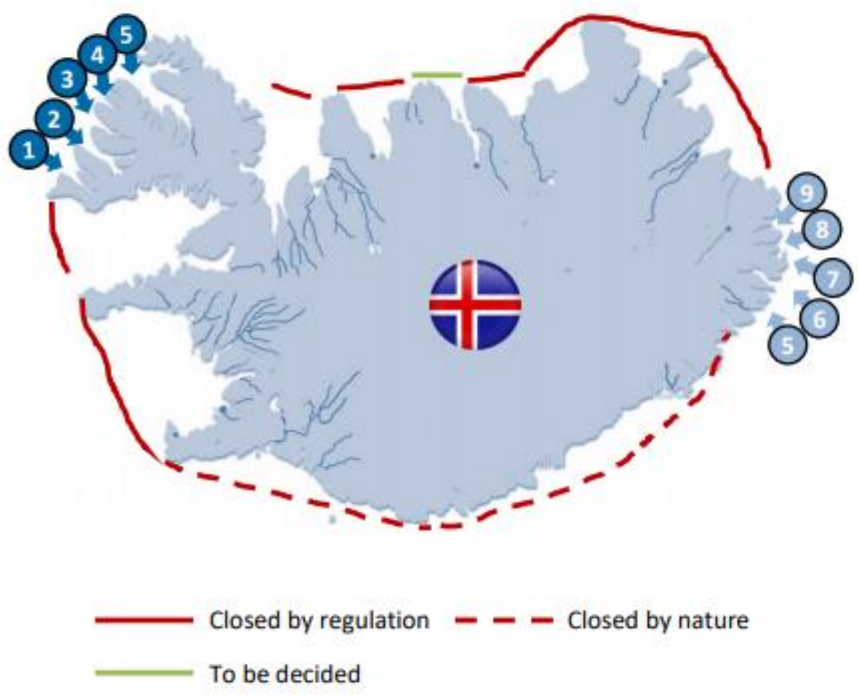

Figure 5 Map of production areas in Iceland. Source: Arnarlax 2020

Fees and taxation

The corporate income tax is 20 percent on Iceland, and the companies are obligated to pay a payroll tax of 6.35 percent (PwC). Fees and taxes specific for aquaculture are the license fees to the environment fund cf. 71/2008 section 20 e, the aquaculture tax cf. Act no 89/2019, and cargo fees and other harbor fees.

The license fee to the environment fund is set to 20 SDR, 10 SRD, or 5 SDR annually for each tonne of MAB the company has of, respectively; fertile salmon, triploid salmon, and rainbow trout and production in closed systems.

The aquaculture tax is based on the average international market price per kg in EUR. The tax level for 2020 was set to 3.5, 0.5, and 2 percent, and comes respectively into force when the salmon price is 4.8 EUR or higher, below 4.3 EUR, and 2 percent when the price is between. This tax does not apply for closed containment produced salmon, and for triploid salmon and rainbow trout the tax level is only half.

The landing fees in the harbor varies from the harbor to harbor, but to illustrate, the harbor in Bíldudalshöfn has, for example, a fee of 0.7 % of the value of all landed farmed fish in the harbor (*Bíldudalshöfn*, n.d.).

Appendix C – Tax System Comparisson

Scenario table:

Criterias	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Positive CIT basis	Yes	Yes	No	No
Employees	10	100	10	100

Tax system comparisson parameters:

NOK EUR	0,100
EURNOK	10,030
EURISK	151,488
SDRISK	181,000
ISKEUR	0,007
Salmon price 1	4,800
Salmon price 2	4,500
Salmon price 3	4,200
Fees and tax rates	
Norway	
CIT	0,220
Payroll	0,130
Export fee	0,006
Production fee pr kg in EUR	0,040
Iceland	
CIT	0,200
Payroll	0,064
Environment Fund	20,000
4,80	0,035
4,50	0,020
4,20	0,005
Harbor	0,007
Other costs	60 % of value

Scenario 1:

Norway	4,80	4,50	4,20
MAB	800,00	800,00	800,00
Production (tons)	1 000,00	1 000,00	1 000,00
Value	4 800 000,00	4 500 000,00	4 200 000,00
Salary	4 000,00	4 000,00	4 000,00
Employees	10,00	10,00	10,00
Other costs	2 880 000,00	2 700 000,00	2 520 000,00
Salary cost	45 200,00	45 200,00	45 200,00
Salary	40 000,00	40 000,00	40 000,00
Payroll tax	5 200,00	5 200,00	5 200,00
Export fee	28 800,00	27 000,00	25 200,00
Production fee	39 879,99	39 879,99	39 879,99
CIT basis	1 806 120,01	1 687 920,01	1 569 720,01
CIT	397 346,40	371 342,40	345 338,40
Total tax and fees	471 226,39	443 422,39	415 618,39
%	0,098	0,099	0,099

Iceland	4,80	4,50	4,20
MAB	800,00	800,00	800,00
Production (tons)	1 000,00	1 000,00	1 000,00
Value	4 800 000,00	4 500 000,00	4 200 000,00
Salary	4 000,00	4 000,00	4 000,00
Employees	10,00	10,00	10,00
Other Costs	2 880 000,00	2 700 000,00	2 520 000,00
Salary cost	42 540,00	850 800,00	850 800,00
Salary	40 000,00	800 000,00	800 000,00
Payroll tax	2 540,00	50 800,00	50 800,00
Environment tax	19 093,63	19 093,63	19 093,63
Production fee	168 000,00	90 000,00	21 000,00
Harbor	33 600,00	31 500,00	29 400,00
CIT Basis	1 696 766,37	1 608 606,37	1 559 706,37
CIT Tax	339 353,27	321 721,27	311 941,27
Totral tax and fees	562 586,90	513 114,90	432 234,90
%	0,117	0,114	0,103

Scenario 2:

Norway	4,80	4,50	4,20
MAB	800,00	800,00	800,00
Production (tons)	1 000,00	1 000,00	1 000,00
Value	4 800 000,00	4 500 000,00	4 200 000,00
Salary	4 000,00	4 000,00	4 000,00
Employees	100,00	100,00	100,00
Other costs	2 880 000,00	2 700 000,00	2 520 000,00
Salary cost	452 000,00	452 000,00	452 000,00
Salary	400 000,00	400 000,00	400 000,00
Payroll tax	52 000,00	52 000,00	52 000,00
Export fee	28 800,00	27 000,00	25 200,00
Production fee	39 879,99	39 879,99	39 879,99
CIT basis	1 399 320,01	1 281 120,01	1 162 920,01
CIT	307 850,40	281 846,40	255 842,40
Total tax and fees	428 530,39	400 726,39	372 922,39
%	0,089	0,089	0,089

Iceland	4,80	4,50	4,20
MAB	800,00	800,00	800,00
Production (tons)	1 000,00	1 000,00	1 000,00
Value	4 800 000,00	4 500 000,00	4 200 000,00
Salary	4 000,00	4 000,00	4 000,00
Employees	100,00	100,00	100,00
Other Costs	2 880 000,00	2 700 000,00	2 520 000,00
Salary cost	425 400,00	850 800,00	850 800,00
Salary	400 000,00	800 000,00	800 000,00
Payroll tax	25 400,00	50 800,00	50 800,00
Environment tax	19 093,63	19 093,63	19 093,63
Production fee	168 000,00	90 000,00	21 000,00
Harbor	33 600,00	31 500,00	29 400,00
CIT Basis	1 673 906,37	1 608 606,37	1 559 706,37
CIT Tax	334 781,27	321 721,27	311 941,27
Totral tax and fees	580 874,90	513 114,90	432 234,90
%	0,121	0,114	0,103

Scenario 3:

Norway	4,80	4,50	4,20
MAB	800,00	800,00	800,00
Production (tons)	1 000,00	1 000,00	1 000,00
Value	4 800 000,00	4 500 000,00	4 200 000,00
Salary	4 000,00	4 000,00	4 000,00
Employees	10,00	10,00	10,00
Other costs	2 880 000,00	2 700 000,00	2 520 000,00
Salary cost	45 200,00	45 200,00	45 200,00
Salary	40 000,00	40 000,00	40 000,00
Payroll tax	5 200,00	5 200,00	5 200,00
Export fee	28 800,00	27 000,00	25 200,00
Production fee	39 879,99	39 879,99	39 879,99
CIT basis	0,00	0,00	0,00
CIT	0,00	0,00	0,00
Total tax and fees	73 879,99	72 079,99	70 279,99
%	0,015	0,016	0,017

Iceland	4,8	4,5	4,2
MAB	800	800	800
Production (tons)	1000	1000	1000
Value	4800000	4500000	4200000
Salary	4000	4000	4000
Employees	10	10	10
Other Costs	2880000	2700000	2520000
Salary cost	42540	850800	850800
Salary	40000	800000	800000
Payroll tax	2540	50800	50800
Environment tax	19093,62873	19093,62873	19093,62873
Production fee	168000	90000	21000
Harbor	33600	31500	29400
CIT Basis	0	0	0
CIT Tax	0	0	0
Totral tax and fees	223233,6287	191393,6287	120293,6287
%	0,047	0,043	0,029

Scenario 4:

Norway	4,80	4,50	4,20
MAB	800,00	800,00	800,00
Production (tons)	1 000,00	1 000,00	1 000,00
Value	4 800 000,00	4 500 000,00	4 200 000,00
Salary	4 000,00	4 000,00	4 000,00
Employees	100,00	100,00	100,00
Other costs	2 880 000,00	2 700 000,00	2 520 000,00
Salary cost	452 000,00	452 000,00	452 000,00
Salary	400 000,00	400 000,00	400 000,00
Payroll tax	52 000,00	52 000,00	52 000,00
Export fee	28 800,00	27 000,00	25 200,00
Production fee	39 879,99	39 879,99	39 879,99
CIT basis	0,00	0,00	0,00
CIT	0,00	0,00	0,00
Total tax and fees	120 679,99	118 879,99	117 079,99
%	0,025	0,026	0,028

Iceland	4,8	4,5	4,2
MAB	800	800	800
Production (tons)	1000	1000	1000
Value	4800000	4500000	4200000
Salary	4000	4000	4000
Employees	100	100	100
Other Costs	2880000	2700000	2520000
Salary cost	425400	850800	850800
Salary	400000	800000	800000
Payroll tax	25400	50800	50800
Environment tax	19093,62873	19093,62873	19093,62873
Production fee	168000	90000	21000
Harbor	33600	31500	29400
CIT Basis	0	0	0
CIT Tax	0	0	0
Totral tax and fees	246093,6287	191393,6287	120293,6287
%	0,051	0,043	0,029