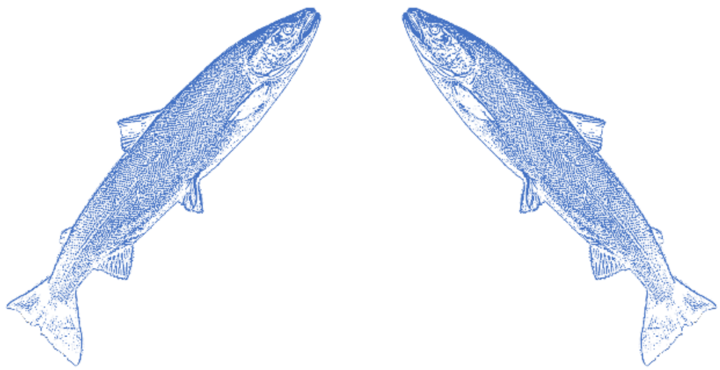

FISH POOL

– A success or failure?

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Abstract

Atlantic salmon farming is an important industry in Norway, it is however a market dominated by a high volatility. Fish Pool was established more than ten years ago, offering futures contracts for risk management. This thesis seeks to investigate whether Fish Pool futures contracts can be viewed as a success or a failure in the terms of four groups of success factors:

1. Factors related to the underlying market
2. Factors related to the actual contracts
3. Factors related to other contracts
4. Factors related to the exchange introducing the contract and its potential users

In order to examine the degree of success for the contract, the price volatility has been investigated with the GARCH procedure and the price volatility has been compared with other commodities. Further, the number of trades and the trading volume has been studied.

The findings suggest that salmon farmers enjoy a high operating margin, which decrease the need for risk management tools such as futures contracts. The prices are still highly volatile, and the traded volume is relatively low. Thus, the Fish Pool futures contract cannot be viewed as a success in the present market situation.

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1.0 Introduction

When Fish Pool was established in 2006, it was no guarantee that it would be a success as a global exchange for price hedging of fish and seafood products. Over the years, several futures contracts for commodity products have been introduced to the market. However, only a few of these contracts have sustained a viable level of trading and economical profitability. In recent years, sales of Fish Pool futures contracts have stagnated and the volatility in the market has risen. This comes as the salmon prices are some of the highest ever recorded.

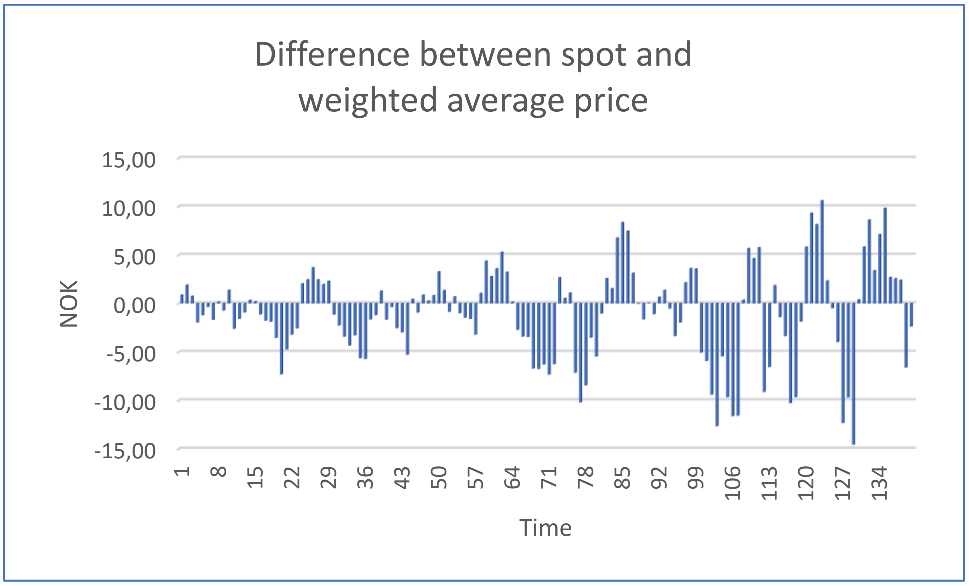

Figure 1 FPI deviation from the spot price. [1]

The contracts at Fish Pool is based on the Fish Pool Index (FPI) which has seen an increased deviation from the spot price since the upstart. As an exchange for futures contracts, it is important for Fish Pool that the FPI is accurate in order to price the futures contracts correctly. This becomes a problem as the salmon price suffers from a high and increasing volatility.

[1] Notice the larger deviations toward the end of the time series.

1.1 Background

Aquaculture is one of the industries in Norway that generates the most value per man-year, ranked as number four in Norway (SINTEF, 2018). Aquaculture is affected by many sources of risk, many of which are difficult to limit or reduce. These risks can be divided into two distinct classes of risk. The first is the type that can for instance be reduced by insurance. Examples of this could be the negative effects from the environment or production risk. The second is the market risk, which to some extent can be handled by derivatives.

The environmental- and production risk can reduce the produced quantity because of increased mortality rates and due to disease contaminations in the form of viral and bacterial infection or parasites. However, it is not only illness that reduce the production in a salmon pen; salmon escaping also poses a threat for the salmon farmers. Technology building on decades of experience has improved the production, making it more profitable and less risky. New technology allows for aquaculture on land, which in principle can be built anywhere. Science has helped greatly in reducing mortality within the pens with better medicine both against viral and bacterial infections, as well as parasites. Threats such as these, along with increased extreme weather, constitute some of the risk that faces the industry which can be managed by insurance.

The other type of risk for the industry is the market risk. Large fluctuations in the salmon price means that the market for salmon is highly volatile. One way of reducing this is by using derivatives, such as futures contracts.

The long coastline of Norway opens great possibilities for aquaculture, which will contribute towards maintaining a high living standard for the general population. Fish exports is an important source of income for the nation (SINTEF, 2018) and it will therefore be quite useful to examine the feasibility of an exchange, prior to committing fully on renewable resources.

Farmed salmon is a highly successful industry in its own right (Oglend & Sikveland, 2008). High volatility in the market would make futures contracts an attractive tool for reducing the risk of large price fluctuations. After Fish Pool was established, it turned out that liquidity and traded quantities were rather low, and the number of trades, as well as traded tons has stagnated on a downward trend in recent years (figure 2).

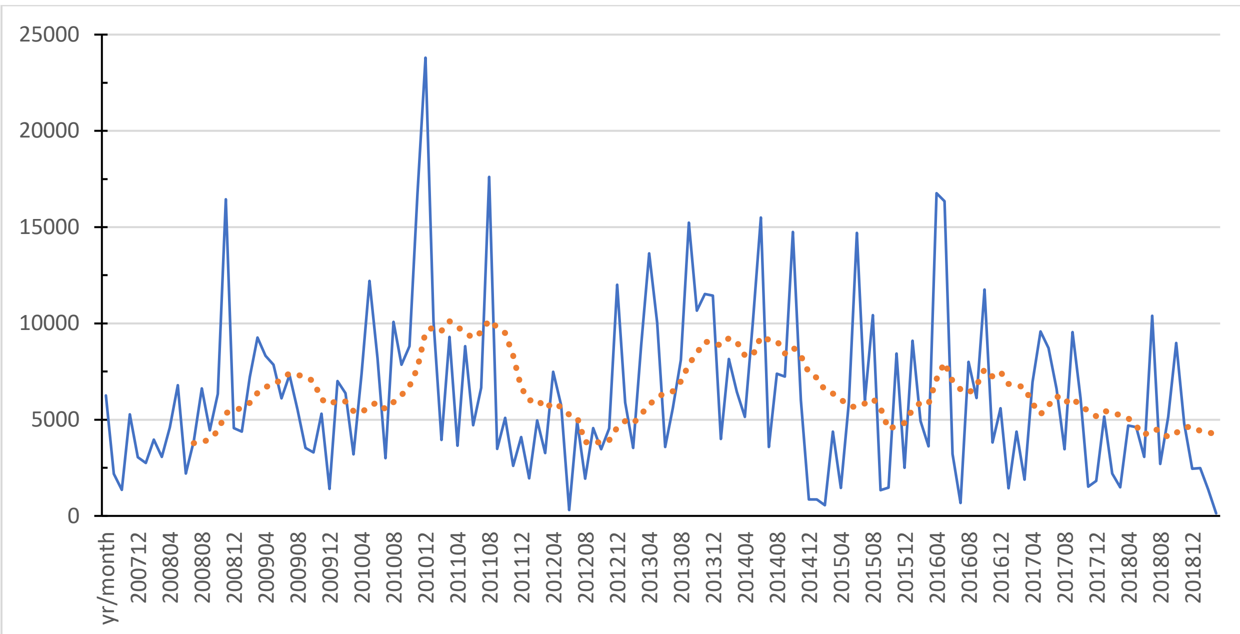

Figure 2 Traded volume in tons per month. [2]

[2] Trendline on a 12-month average. Y-axis in thousands of NOK. Notice the downward trend since September 2016.

1.2 Research problem

The thesis seeks to examine how successful Fish Pool has been, in the sense that it has fulfilled the success factors and prerequisites for a futures exchange. This will be done in the context provided above and our research problem is:

Is the Fish Pool salmon futures contract a success or a failure?

To answer the research problem, it will be necessary to isolate the success factors of an exchange for commodity products and study them separately. This will then provide sufficient information to compare with previous literature on similar commodity exchanges to determine whether or not Fish Pool has been a successful futures exchange.

Pennings & Meulenberg (1998) pointed out that the success of a futures contract can be measured in terms of volume, which is a function of contract and cash market size, hedge ratio and velocity (equation 1(1). The thesis will examine the performance of salmon contracts as traded on Fish Pool. The primary metrics by which this will be examined are found in equation 1. These variables may seem easy to understand and extrapolate, however this is not the case for all of them. A large volume means that a contract is successful. While a higher volume denotes a successful contract, the resulting number should be read in relative terms. The cash market size is a property of the underlying market. Futures contract size is a property of the actual contract that is determined by the exchange. Hedge ratio can be seen in relation to other contracts. The cash market size, futures contract size and the hedging ratio are easily obtained. A hedging ratio of *1* implies that the production in its entirety is hedged in the futures contract. Velocity is measured in terms of how many times a contract is traded within a specific time period. A velocity larger than *1* indicates that trading of the contract includes both hedging and speculative trade, because then the contracts would be traded more than once.

$$Volume = \frac{Cash\ market\ size}{Futures\ contract\ size} \cdot Hedging\ ratio \cdot Velocity \tag{1}$$

Velocity is affected by the interest of the players using the contract, especially speculators. They tend to be attracted by volatile markets with large potential for payoffs. The success factors for an exchange has been studied by Bergfjord (2007) and will be explained in greater detail in chapter 2.2. To summarize them in more formal terms:

1. Factors related to the underlying market.
2. Factors related to the actual contract.
3. Factors related to other futures contracts
4. Factors related to the exchange introducing the contract and its potential users

We will examine all of these key points in chapter 2 and the main focus of this thesis will be how they affect the Fish Pool contracts.

1.3 Purpose

Previous literature has implied that commodity markets for futures contracts has had a somewhat frayed history of success. From 1929 to 1986, more than 80% of the futures contracts failed, which could be a topic of concern when introducing new contracts (Black, 1986, p. 1). The purpose of the thesis is to see whether Fish Pool is successful at limiting the risk exposure for the salmon industry; and by extension limiting risk for the national economy in the future, in the context of expanded investment in aquaculture. Information about this will be useful knowledge for future possible adjustments in Fish Pool or other futures contract exchanges. Learning from previous mistakes could help avoid pitfalls and exploit the good behaviours of a market to facilitate steady growth.

1.4 About Fish Pool

Fish Pool ASA is an international commodity exchange based in Bergen, Norway. It deals with futures contracts for salmon. The company was established in 2005 (Fish Pool, n.d.a), and the first trading took place in May 2006 (Fish Pool, 2007). The largest shareholder in Fish Pool is Oslo Børs ASA, holding 96,96% of the shares. Other shareholders hold a comparatively small fraction of the shares (Aksjeeierne.no, 2019). They have experienced good growth patterns in traded volume in the first couple of year since the foundation, but this has since changed. Their main objective is to reduce risk exposure for sellers and buyers of Atlantic salmon, and to increase the predictability of spot prices in the salmon market.

As mentioned, Fish Pool facilitates trading of futures contracts on salmon. This is a contract between a seller and a buyer, where the seller commits to deliver one metric ton of salmon of a specified quality standard to the buyer at a specified time. This will be covered in greater detail in chapter 2.1. They do not provide forecasting or market prognosis for the traders in the market, only the current market for the futures contracts. Trade members grew steadily from the beginning. Contracts at Fish Pool were cleared through NOS Clearing the first years however, this clearinghouse was purchased by Nasdaq in 2012. In 2014 Nasdaq was fully integrated with NOS Clearing, and from April 2014 Nasdaq were responsible for the clearing at Fish Pool (Fish Pool, 2015).

Nasdaq introduced stricter formal requirements on the members and their equity. This resulted in a significant reduction in trade members as many were unable to comply with Nasdaq's demands. While this may seem worrying, it is important to note that some members are able to trade through general clearing members (GCM). Fish Pool states that it is increasingly important to get new banks as GCM to facilitate more trade (Fish Pool, 2016). Fish Pool has now been an active marketplace for over ten years, and now is a good time to investigate to which degree Fish Pool has achieved the goal of reducing risk.

1.5 Limitations

This thesis will examine the performance of Fish Pool compared to similar commodity markets by looking at the underlying market, the contract itself, other contracts, its users and the exchange itself. The underlying market will have the volatility of the spot prices investigated through a strictly econometric analysis.

The analysis will use data from the period between September 2007 to April 2019, which will provide some limitations as to historical events. For example, trading started at Fish Pool in 2006 but we only include data from September 2007 (about one and a half year later) because we expect the trading to mature somewhat after this amount of time. It is also using monthly data, which will limit the resolution to some degree compared to weekly data. The data used for correlation and cointegration of the spot price for different commodities consists of time series from a similar timescale. These time series go from December 2006 to June 2017 to reflect the same period.

The thesis will not control for the impact of regulatory changes by the European Union, Russia or other national state organs, nor for changing of the clearing house.

1.6 Structure of the thesis

The paper will be sectioned into five main chapters, with several subchapters each. We have decided to number these, as well as the equations, illustrations and tables to ease navigation.

In the introductory chapter of the thesis, we will describe the company, Fish Pool, and set the context for the research problem. This includes a brief historical overview over the company from its foundation in 2006 to April 2019. This chapter will also include a discussion about limitations of the study.

The second chapter contains a review of all the theoretical models and previous literature that are relevant for the thesis.

In the third chapter, we will present our data and review the methodology by which we will conduct our analysis, to construct a framework for answering the research problem.

The fourth chapter consists of two main bodies. This is where we discuss the findings from chapter three and study the results carefully.

The fifth chapter contains a brief summary of the observations and findings from the previous chapter, followed by the conclusion.

2.0 Theory

In this chapter we will go through relevant literature and theories that we will use to support our discussion and understanding of Fish Pool. Many different aspects affect the success of a futures contract, Fish Pool is no exception from these.

2.1 Futures contract

A futures contract is in many ways similar to a forward contract, in the sense that it is an agreement between two parties to buy or sell an asset at a certain point in the future for a certain price. The main difference between a futures contract and a forward contract is that futures contracts are primarily traded at an exchange. Futures contracts have standardized specified features of the contract, such as volume, quality and delivery conditions. This differs from forward contracts, that are over the counter and the participants are free to negotiate terms of the contract (Hull, 2018, p. 30).

There are two positions when trading; the long position and the short position. The long position is held by the participant that has agreed to *buy* the underlying asset while the short position is held by the participant who agrees to *sell* the underlying asset (Hull, 2018, p. 28).

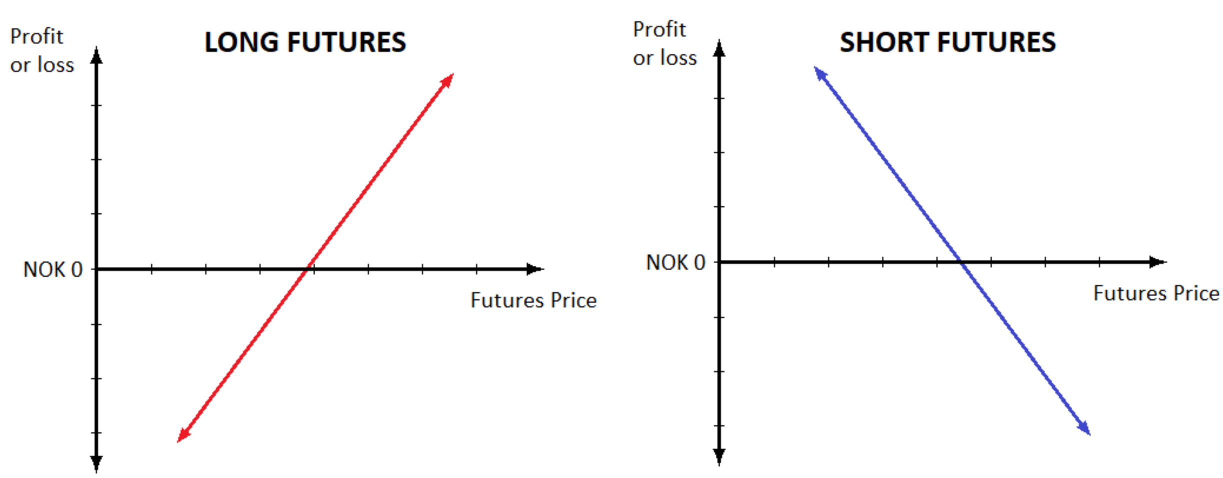

Figure 3 Long and short positions.

When trading with others, especially when the participants are unfamiliar with each other, there is a risk that one of the participants fail to fulfil its obligations towards the other party. This is where the exchange becomes relevant. Instead of the participants trading directly with each other, the traders make their deals through the exchange. The exchange takes care of the clearing, which is secured with a margin account, leaving no credit risk for the traders (Hull, 2018, p. 30).

There are three main groups of traders in the futures market; hedgers, speculators and arbitrageurs (Hull, 2018, p. 33):

- Hedgers use futures contracts to transfer risk since they are exposed to a volatile spot market. This could typically be salmon farmers or salmon processing companies.
- Speculators use futures contracts to bet on which direction a market will go.
- Arbitrageurs take positions in two or more contracts that offsets one another to obtain a profit.

Fish Pool uses Nasdaq as clearinghouse, as an intermediary between buyer and seller. Nasdaq's function is to make sure both players honour their part of the contract, maintaining the margin levels, reporting the trading information and regulating the traded contracts (Fish Pool, n.d.b). When entering the contract, the traders have to deposit funds into a margin account. This is known as the initial margin and is a usually a fixed share of the contract value. Nasdaq use a portfolio risk, known as the margin requirement, which is basically the same. This is calculated based on liquidity and volatility of the account. This particular margin should cover 99,2% of all expected price movements within the time it takes to close the portfolio for a trade member that fails to honour his obligations. To secure that the traders are able to fulfil their obligations towards the exchange, they have to keep the funds on the margin account above a certain level, known as the maintenance margin. This margin will be settled daily against the Fish Pool Forward Prices (Fish Pool, n.d.b). If the price of the contract falls below the maintenance margin, they will get a margin call and be required to deposit more funds into the account. Should a trader fail to do so, the clearinghouse will sell the contract and thereby close out the trader's position (Hull, 2018, pp. 51-53).

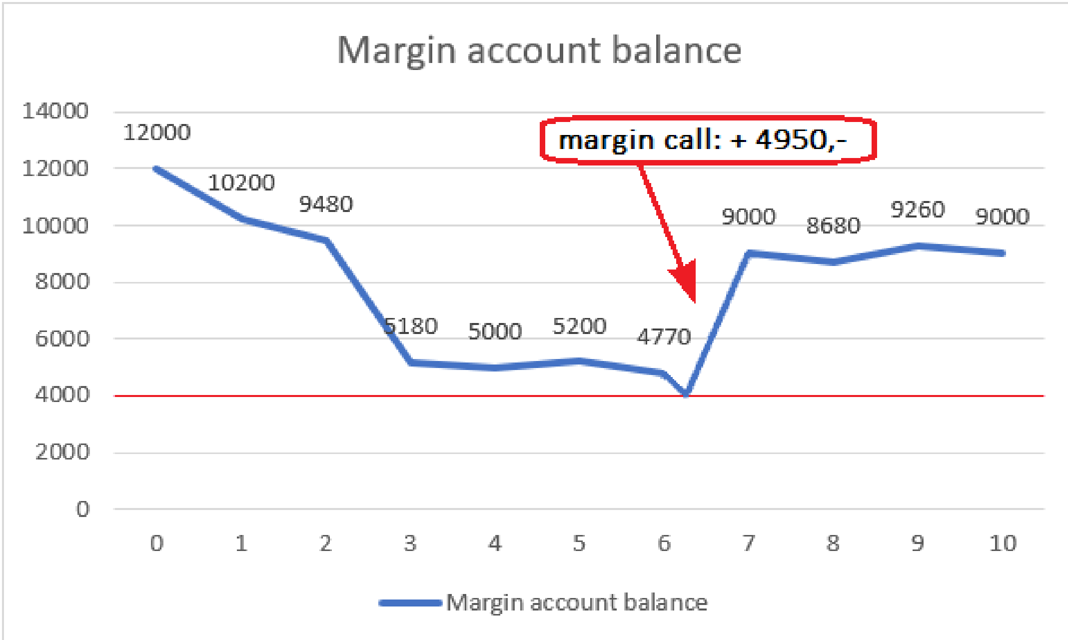

Figure 4 Margin call

Consider figure 4 where the maintenance margin is set at 4’000,- while the margin account has a starting balance of 12’000,-. From period 6 to 7 the margin account drops below the maintenance margin and the owner is contacted with a margin call. He then deposits 4’950,- and maintains his position.

2.1.1 Payoff

The payoff from a futures trade can be illustrated with the graphs below (figure 5). The payoff is in this context the term used for the cash realized by the holder of a futures contract at its maturation. At what point a trader makes a profit depends on what position the trader has entered.

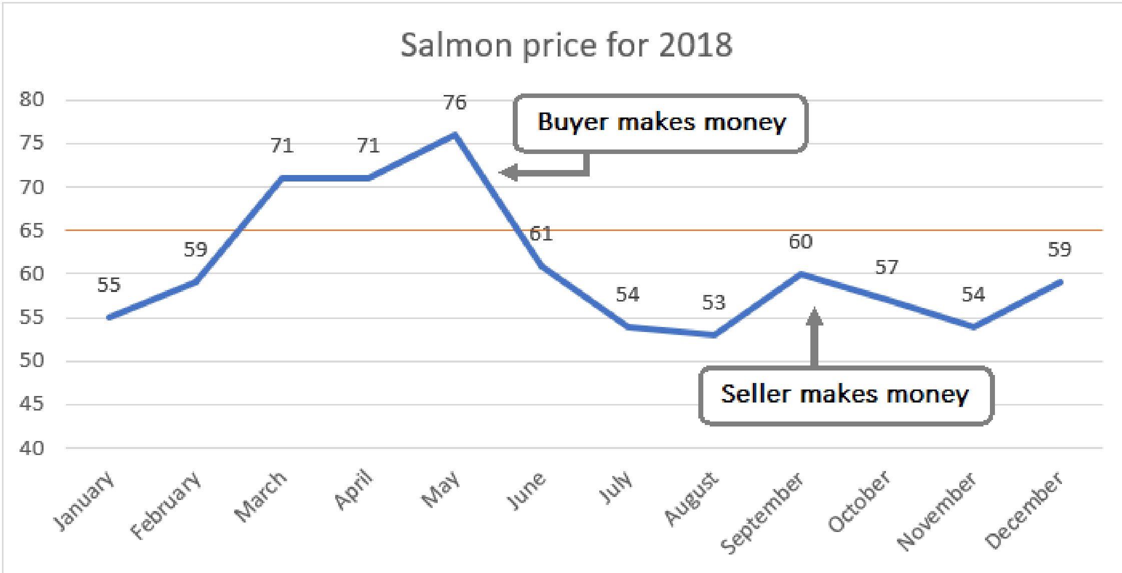

Figure 5 Payoff [3]

Having a contract priced at 65 NOK, the buyer would make money when the spot price is higher than 65 NOK, while the seller makes money when the spot price is below 65 NOK.

2.1.2 Hedging and risk management with futures contracts

Futures contracts have proven to be a useful tool for limiting risk exposure. By obtaining a short position or a long position, the participants can lock in at a certain price and secure a profit. A salmon farmer could enter a short position in a futures market, and by doing so securing himself a price higher than his expected production costs and thereby gain a safe net profit.

Hedgers primarily want to limit their risk in the income department. Hedging with futures contracts can be done either with a contract on the same asset as the underlying asset, or with a contract on a closely correlated asset. This is known as a cross hedge. An example of a cross hedge can be when an airline company wants to secure themselves against price change in jet

[3] Illustration based on: http://fishpool.eu/products/concept/

fuel. Since there are no futures contracts for jet fuel available for trade, the airline company can choose to use a futures contract on crude oil to reduce its exposure to price change.

If a market has high volatility, it could create a need for price securing mechanisms, such as futures contracts. It is useful to know the optimal number of futures contracts needed to minimize the risk when hedging using futures contracts. Equation 2 below is used for estimating the ratio of futures contracts a hedger should buy to minimize the expected variance. This is known as the minimum variance hedging ratio, or optimal hedging ratio (h^*) (Hull, 2018, pp. 80-82).

$$h^* = \rho \frac{\sigma_S}{\sigma_F} \tag{2}$$

Where ρ denotes the correlation between the spot price and the futures price. σ_S and σ_F is the standard deviation of the changes in spot price and the futures price, respectively. The higher the volatility in spot price, the more futures contracts would be required to offset the risk.

2.2 Previous literature

Futures contracts have been traded for generations, and much research have been conducted to elaborate on the subject. In order to investigate the degree to which Fish Pool is a success or not, the thesis will work on support from previous literature. But first, what is a successful contract? Black (1986) express it like this on page 1:

> "A successful contract innovation attracts a lot of trading interest, draws many people to the trading pit and generate substantial order flow from off-the-floor participants."

Bergfjord (2007) identified four primary groups of factors that affect the possibility of success for a futures contract. These will be explained in detail in the following subchapters and are listed in table 1.

Determinants of success	
1	Factors related to the underlying commodity market
2	Factors related to the actual contract
3	Factors related to other futures contracts
4	Factors related to the exchange introducing the contract and its potential users

Table 1 Success factors

2.2.1 Factors related to the underlying commodity market

For a futures contract to succeed, several factors play a role. They will in part influence the hedging ratio (equation 2) and to some extent the attractiveness for potential speculators (Bergfjord, 2007).

One of the objectives of using a futures contract is to offset some of the price risk in the spot market. Thus, a market with low variation in spot prices would not raise the need for futures contracts. A market with stable prices would not be interesting for speculators, as there would be little potential for large profits from their investments.

To attract participants to the futures market, the underlying market needs to be of a considerable size and have active trading. A large spot market with several participants and active trading is harder to manipulate, which increases the credibility of the market.

For investors and speculators to be interested in buying contracts, they would need to know the quality of the underlying asset. A widely accepted grading system makes it easier to clarify the quality of the underlying asset and hence easier for the clearinghouse to fulfil its obligation towards the traders. An example of such system could be grading salmon according to weight.

The first futures markets were products that could be stored without decreasing the quality, such as cotton, grains, tin and cocoa. With technological development the storage opportunities improved drastically, allowing previously perishable products to be stored. As an example, salmon can now be stored in refrigerators for transport. This opened the futures market for new products such as ham, pork bellies and shrimp (Black, 1986, pp. 6-7).

Later, it has been found that today’s futures price can be a good estimator of the spot price in a future month. This realization has made it possible to trade seasonally produced products in the futures market. Further, cash settlement where the participants transfer the cash rather than the delivery of the physical asset, has become a normal method of settlement. This has in many cases made storability a less important factor for success (Black, 1986, p. 7).

Free flow of information regarding the spot prices is important for speculators to be attracted to participate in the market. If the spot price were a private matter between the buyers and sellers, it would be difficult for speculators to know what a fair spot price would be and determining the chance of a risk premium would be difficult.

Bergfjord (2007) points out that there must be little obstructions for the goods to reach the market and that the underlying market should ideally be perfectly competitive. This is a two-sided matter; there cannot be any participants that control the market, neither government price controlling systems nor monopolists, and the transaction cost or the delivery cost has to be relatively low.

Vertical integration is a term used to describe the situation when a player in the market controls two or more links in the supply chain. Previous studies conclude that there has been a substantial growth in productivity associated with downstream activities (processing of the goods prior to actual sale) (Kvaløy & Tveterås, 2008; Asche, Roll, Sandvold, Sørvig, & Zhang, 2013). More vertical integration seems to work poorly in conjunction with futures contracts, which results in a declining spot price (Asche, Misund, & Oglend, 2016)**.** While companies reduce their own risks by becoming more vertically integrated, the overall market they operate in, becomes more vulnerable to manipulation (Bergfjord, 2007). He points out that an increasing share of the salmon production is being concentrated in fewer, larger companies. This means that the underlying market should consist of only a limited amount of vertically integrated companies, to attract more participants (Asche, Misund, & Oglend, 2016). It makes the market more vulnerable to manipulation (Bergfjord, 2007). Thus, the underlying market should consist of little vertical integration to attract more participants.

2.2.2 Factors related to the actual contract

Bergfjord (2007) summarize the three main prerequisites for the actual futures contract to succeed as: the contract has to be designed in a way that attract both hedgers and speculators and have some degree of flexibility without being too vulnerable to manipulation. This view is shared by other research (Gray, 1966, pp. 121-122) and points out that to attract the hedgers, the contract must be in compliance with the physical market. The flexibility could regard factors such as the delivery terms, months and locations. Further, Gray (1966, p. 122) says that speculators are necessary, primarily to achieve a balanced composition of long and short positions. He found that hedgers tend to take short positions, and that speculators are necessary, both to even out this tendency and to reach an optimal level of trading.

Flexibility is the range of acceptable deviation from a point of reference. It is the more problematic of the prerequisites because it has the potential to destroy the market. This is achieved by allowing for delivery to be postponed or advanced, small deviations from the stated grade and changes of delivery locations. The point where this becomes an issue is when rational investors exploit the flexibility of a contract for their own gains. This is one of the reasons for the failure of contracts (Tashjian & McConnell, 1989; Thompson, Garcia, & Wildman, 1996; Sanders & Manfredo, 2002; Martinez-Garmendia & Anderson, 1999). Despite the relative prices behaving according to the specifications of the contract, the rational seller will eventually try to deliver the specified grade that is priced “too good to be true” in the contract. In anticipation of this, the buyer will reduce his offers, and essentially flood the market with lower bids. This death spiral is the cause for many failed futures contracts.

To summarize, the contract needs to be:

1. Attractive to hedgers
2. Attractive to speculators
3. Flexible, yet robust against manipulation

2.2.3 Factors related to other futures contracts

From previous literature we find a broad agreement regarding the presence of cross-hedging possibilities; the presence of a closely correlated contract would decrease the need, and thereby the probability of success for a new futures contract. Salmon contracts could be attractive for other commodities, such as soybeans, to hedge against price risk in their markets. However, the presence of an already pre-existing contract with higher correlation spoils this opportunity.

Residual risk is the difference between the unhedged risk that remains when using a correlated futures contract instead of the futures contract for the own product (Vassdal, 1995). In other terms, it is the risk that remains after the impact of the cross-hedge are subtracted from the inherent risk of the commodity (figure 6).

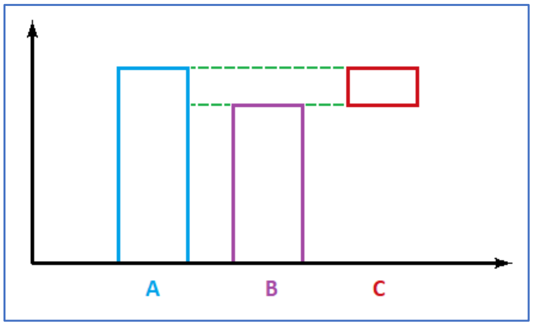

Figure 6 Residual risk [4]

Black (1986, p. 24) states:

> "*If a futures contract already exists for a close substitute, the reduction in residual risk derived from the new "own" hedge (compared with the cross hedge) is likely to be small, and may not outweigh the cost of transaction in the less liquid, newer market.*"

Bergfjord (2007) looked at correlations between salmon prices and the prices of other commodities. In his research salmon prices had a poor correlation with the other commodities he looked at. This indicates that the residual risk would be high, and a salmon futures contract could therefore be useful.

2.2.4 Factors related to the exchange introducing the contract and its potential users

When it comes to the introduction of the futures contract, Silber (1981) found that contracts introduced by large exchanges had much larger chances to succeed than contracts introduced by small exchanges. This makes sense as larger exchanges might have a bigger number of established users. The threshold to start trading a new contract at the exchange is probably lower for a costumer that already have established a relation with the exchange, than for costumers that have never traded at the exchange.

[4] A represents the inherent risk for an asset, B the impact of the cross-hedge and C the residual risk.

The geographical location of an electronic marketplace might not affect the traded volume at an exchange dealing with cash settlement. However, as Norway is one of the largest producers of farmed salmon in the world, a location in Norway could attract many of the potential hedgers. A big part of the production (1'055'000 metrics tons in 2018[5]) is exported, and a Norwegian exchange might have to focus more on the marketing to reach potential investors and traders in larger foreign markets.

The potential users of the market are important. A market with more risk-averse hedgers will have higher hedge ratio, hence a contract will be more likely to succeed (Bergfjord, 2007). This does not seem to be the case for the Norwegian fish farmers. Bergfjord (2006) published a survey on Norwegian fish farmers, showing that they think of fish-farming as a risky industry, but still the farmers are comfortable with the level of risk they are exposed to.

2.3 Liquidity

An important matter for traders is liquidity. A liquid asset is an asset that is traded frequently. Users of futures contracts measure liquidity in terms of how easy it is to buy and sell the futures contracts they are interested in. The usual primary gauges of liquidity are (Lerman, 2018):

- volume
- open interest
- a narrow bid/offer spread

Some of these could be relatively complicated to quantify and put a number on. In figure 7 we can see that the primary metrics are price and quantity. Price is the cost of the asset in question, whether it is what the seller wants for it, or what the buyer is willing to pay for it. This is used to determine the ask/bid spread and liquidity models that use this metric are exogenous. Quantity is used to measure the position size of the seller/buyer in relation to the market. Models that use this are called endogenous liquidity models.

[5] https://e24.no/naeringsliv/laks/trippelrekord-for-norsk-lakseeksport/24532858)-

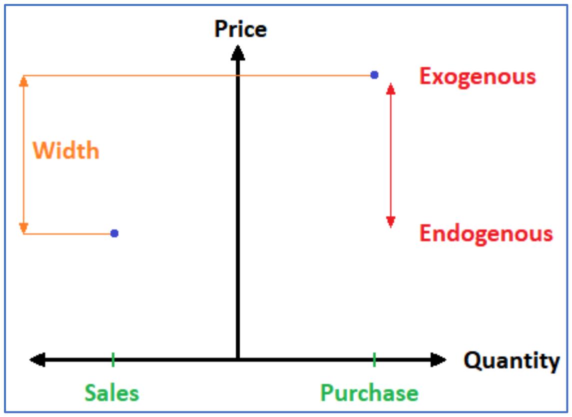

Figure 7 Liquidity

2.4 Volatility

All markets will swing up and down depending on factors that affect the different input and output variables. The term volatility, also known as standard deviation, describes how often, and the magnitude of these swings. As an example, if the crops fail one year, then you might expect an increase in food prices. If the crops do exceptionally well, an overproduction situation has occurred, resulting in lower food prices. If these two scenarios occur one year after the other, then the volatility of the food market has increased. This is a problem recognized by the salmon farmers as well as traders and is likely to contribute much to their desire to use futures contracts for hedging the prices and reduce their risk exposure.

Volatility is caused by a wide range of factors, some of which have a direct impact while others may have a more indirect impact by affecting the supply chain. A discussion on these will be carried out below (in section 2.4.2). It is important to note that the list of factors affecting volatility in the market for farmed salmon includes, but is not limited to the content of those subchapters.

Price uncertainty creates a demand for futures contracts, as hedgers seek to limit their risk exposure, as well as attracting speculators. It is therefore important to understand the causes for price uncertainty, or volatility, in the salmon market. Previous literature on volatility in the salmon price is limited by the information about weekly prices only being available since 1995 (Misund, 2018). This means that most literature only looks at monthly salmon prices going back to 1980, which in itself is useful information for studying volatility on a large timescale, albeit with some lack in detail.

Farmed salmon has seen a good growth in profitability since the beginning. Growth in productivity reduces production costs before reducing the price of the end product, because the producers attempt to adjust to the market. This could lead to increased price volatility, which is the case for farmed salmon. High volatility increases the demand for instruments meant to secure prices, or at the very least limit the exposure of risk (Misund, 2018). Studies show that the salmon price has, since 2000-2005, largely been determined by input factors (Asche & Oglend, 2016). This means that production, and related costs such as fish food, taxation, transaction costs and transport, is the key aspect determining the price.

As with any demand/supply relationship, overproduction leads to a fall in prices. This results in reduced production in the next period which leads to increased prices. This seems to be a big issue that plagues the farmed salmon industry. In other words, the salmon industry seems to struggle with adapting to the market. Deeper knowledge about trends in the volatility is key to pricing futures contracts. Good estimates of the volatility in the future is important to the valuation equation for the contract, which is calculated from equation 3 below. The prices in the NSI is calculated from the weekly average of the weight classes as seen in equation 4.

$$FPI = NSI \cdot 0{,}85 + FPI_{buyers\ index} \cdot 0{,}1 + SSB \cdot 0{,}05 \tag{3}$$

$$NSI = 0{,}3 \cdot (3 - 4\ kg) + 0{,}4 \cdot (4 - 5\ kg) + 0{,}3 \cdot (5 - 6\ kg) \tag{4}$$

Where NSI denotes the Nasdaq Salmon Index (which in turn is used in equation 3), $FPI_{buyers\ index}$ is the large purchasers purchase price and SSB is the Statistics Norway customs statistics (SSB) on Norwegian exports.

The salmon market is plagued by limited knowledge about seasonal variations in volatility. To examine trends and seasonal variations, a seasonal trend decomposition by Loess (STL) could be applied (Cleveland, Cleveland, McRea, & Terpenning, 1990). The effect of seasonal variation on the total volatility appear to be rather moderate in previous work, and a small hint at asymmetry that is not properly captured by an ARMA-GARCH-model (Misund, 2018).

The interest for risk-managing tools among salmon farmers seems to be rather moderate (Bergfjord, 2007; Asche, Misund, & Oglend, 2016). This has the potential to affect the farming companies' investments, profitability and creditworthiness in the negative direction because of the volatility. The farmers, as well as lenders and the authorities should be more aware of this. Mohn & Misund (2009) found that oil companies' investments are stimulated positively by volatility in the oil price. The same could be true for the salmon industry.

To summarize, it could be said that there are two main sources of price volatility in the farmed salmon business; *volume uncertainty* and *market risk*. Previous studies claim that volume uncertainty is highly significant (Asche & Tveterås, 1999; Tveterås, 1999; Kumbhakar & Tveterås, 2003) and that market risk is high and increasing (Oglend, 2013; Bloznelis, 2016).

2.4.1 Market risk

Actors will start to demand price security at higher levels of market risk. Perhaps the largest source of market risk in the farmed salmon industry is the limited possibilities for delayed harvest of the salmon. Bigger salmon increase the possibility for maturation which severely decreases quality. This means that harvesting the stock needs to take place within a relatively short period of time and requires operational planning over longer periods to prevent economical losses (figure 8). While this seems like a source of market security, it is only so for the buyers and not the salmon farmers (Misund, 2018), because they would prefer to sell the fish within this time window as they get better prices here.

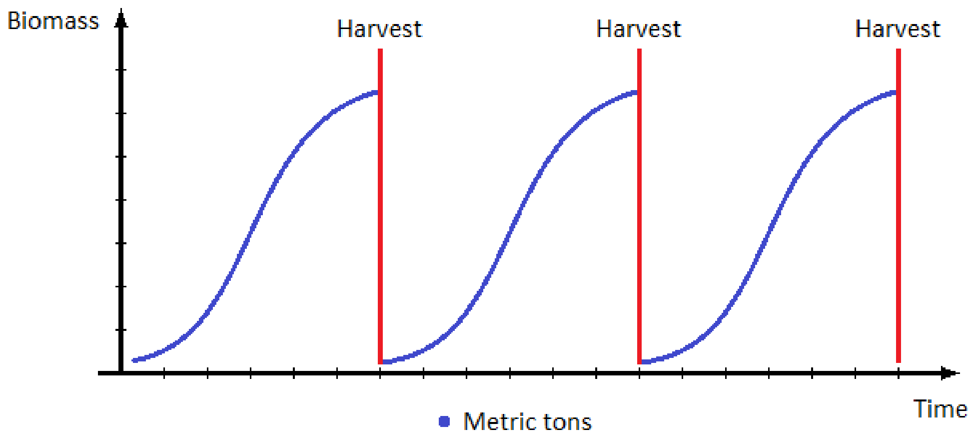

Figure 8 Harvesting cycles for a fish farmer.

The amount of biomass in a single salmon enclosure usually tend to follow the pattern in figure 8. The fish is usually harvested right before peak biomass is obtained because the increase in biomass is too small and greater profitability is achieved by putting out a new stock on an earlier stage at this point. The farmers want to harvest and sell the biomass as quickly as possible to minimize the downtime (Samuelson, 1976, p. 477).

2.4.2 Volume uncertainty

A plethora of factors attribute to volume uncertainty. Some of these may be more difficult to avoid compared to the others, but nevertheless worth a mention in this context. These have been distilled down to five main groups as shown in table 2 and will be discussed in detail in the following section. Uncertainty in produced volume is not just a problem for the farmers. Buyers and speculators will also experience this on their end, as it becomes difficult to predict their future turnover.

Source of uncertainty	Short description
Disease problems	*Pancreas disease* (PD) and infectious salmon anaemia (ISA)
Parasite problems	*Lepeophtheirus salmonis* and *Parvicapsula pseudobranchiola.*
Escape problems	Fish escaping their enclosures.
Sales contracts	Derivative contracts.
Governmental regulations	Limiting medicine availability type and amount.

Table 2 Sources of volume uncertainty

2.4.2.1 Disease problems

Salmon is like all living things prone to various types of sickness and diseases. Many of these reduces the quality of the salmon, rendering it useless in a sales situation. The fish are bred in large pens and live in very tight conditions which is ideal for spreading of diseases. This means, that if one fish catches a disease, the entire stock will eventually be contaminated and in need of either treatment or termination depending on the severity of the disease. This is naturally a large source of uncertainty for the volume. Examples are infectious *pancreatic necrosis*, infectious salmon anemia and *Pancreas disease* (Håstein, 2018).

2.4.2.2 Parasite problems

In later years, lice (*lepeophtheirus salmonis*) have been a publicly known problem for the salmon industry. They are not the only known parasite that latches onto the fish. *Parvicapsula pseudobranchiola* is also a very big problem. It remains an issue because of the cramped conditions in the enclosures. These small creatures reduce the quality and thus the volume of sellable fish (Håstein, 2018).

2.4.2.3 Escape problems

Atlantic salmon is farmed in big, cylindrical enclosures of netting in the ocean. These are prone to breakage as a result of harsh elements, allowing fish to escape through small holes. This is a huge problem for the native (wild) salmon population because the escapees are mating with it and introduce undesired genetic traits. It is also a source of concern with the farmers because they lose revenue from fish they could otherwise have sold.

2.4.2.4 Sales contracts

There has been an increase in usage of sales contracts in the aquaculture industry (Kvaløy & Tveterås, 2008; Larsen & Asche, 2011). This will lead to a decrease in the volume of salmon sold in the spot market which means that the full capacity of the industry may not be utilized. In other words, the farmers do not produce more salmon than they have contracts for.

2.4.2.5 Governmental regulations

Restrictions on allowed amounts and types of medicine in the enclosures limits the health of the fish. By extension it also limits how much biomass can be produced. Additional regulation on the total amount produced, exported to each country and sold domestically further complicates matters. While these remain constant until a new regulation scheme is introduced it serves as an upper limit for the amount that can be produced. This is a source of uncertainty during the negotiations and implementational phases.

3.0 Methodology and Data

To evaluate whether Fish Pool is a success or a failure, we will look at the business through the lens of the success factors. These have to be explored in turns and will require different methods, which will be discussed in the following chapters.

3.1 Dataset

In order to examine the success of Fish Pool, different data is used.

As spot price for the analysis of volatility, we use the historical prices from Fish Pool. The spot prices are downloaded directly from their webpages.[6] This data is monthly and are a weighted average of the weekly data.

Variable	**Average**	**Std. deviation**	**Min**	**25 percentile**	**Median**	**75 percentile**	**Max**
Spot price	41,94	14,70	20,64	28,77	39,34	53,23	76,02

Table 3 Descriptive statistics, spot price of salmon (nominal price).

The data set consists of monthly prices from September 2007 to April 2019, for a total of 140 observations. It was compiled from the original trade history which had to be converted into monthly datapoints. Further, the FPI is primarily based on the prices of different weight classes of salmon. The information regarding these prices were also retrieved from the webpage of Fish Pool.[7]

[6] Spot prices historical http://fishpool.eu/price-information/spot-prices/history/

[7] http://fishpool.eu/price-information/spot-prices/weekly-details/

Information about trades at Fish Pool, both amount of tons and number of trades is accessible from Salmonprice.com.[8] As mentioned, a futures contract on salmon is for one metric to and this simplifies the process of drawing information from the statistics.

Data for numbers of trades and numbers of tons traded is gathered from salmonprice.com. For this part we use data from September 2007 to March 2019, a total of 139 months.

Regarding the data for the spot market, it is retrieved from the Norwegian Directorate of Fisheries. This includes data about the cost per produced kilo, the operating margin and the amount of national sales of salmon in the spot market.[9]

To compare spot prices for commodities; salmon, lamb, corn, shrimp, poultry and soybeans prices were retrieved from Quandl.com and for this part the prices are denoted in USD.[10] This data ranges from December 2006 to June 2017. This is monthly data, a total of 127 observations for each of the commodities.

In addition, Fish Pool have shared data regarding number of trading members and the volume share for the different the trader segments via email.

[8] https://salmonprice.com/

[9] Sales spot market https://www.fiskeridir.no/Akvakultur/Statistikk-akvakultur/Akvakulturstatistikk-tidsserier/Laks-regnbueoerret-og-oerret/Matfiskproduksjon
Cost and margin https://www.fiskeridir.no/Akvakultur/Statistikk-akvakultur/Loennsomhetsundersoekelse-for-laks-og-regnbueoerret/Matfiskproduksjon-laks-og-regnbueoerret

[10] Lamb https://www.quandl.com/data/ODA/PLAMB_USD-Lamb-Price
Shrimp https://www.quandl.com/data/ODA/PSHRI_USD-Shrimp-Price
Poultry https://www.quandl.com/data/ODA/PPOULT_USD-Poultry-Price
Salmon https://www.quandl.com/data/ODA/PSALM_USD-Fish-Salmon-Price
Soybeans https://www.quandl.com/data/ODA/PSOYB_USD-Soybeans-Price
Corn/maize https://www.quandl.com/data/ODA/PMAIZMT_USD-Maize-Corn-Price

3.2 Factors related to the underlying market

As outlined in chapter 2.2.1, we will study three main topics; volatility, homogeneity and vertical integration. These topics will explore the underlying market and reveal the nature of its behaviour.

3.2.1 Volatility

We will explore the volatility with the GARCH method as explained below. This information will tell us something about the nature of volatility in the spot market for the salmon contract, with the hypothesis that it has a high and increasing volatility. There are a great number of potential GARCH models that can be applied with different values of the input variables. These will vary greatly in their abilities to capture the properties of the conditional returns and variance. We have to decide which model is best suited for our needs. We will pick the best of several models based on the smallest value of the information criteria.

3.2.2 The GARCH procedure

The dataset has the descriptive statistics as seen in table 3 and consists of 140 observations from September 2007 through April 2019, however the last observation is omitted from the analysis because it is an incomplete month. The average spot price is 41,94 kr/kg with a standard deviation of 14,70 kr/kg. This could give the wrong impression because the price has been growing and declining repeatedly within the observed period. Because the spot price has risen so much during the period we will study, a typical average and standard deviation is thus useless for describing the volatility in our context.

The analysis itself will be conducted with a computer software known as RStudio. This is a powerful software package for statistical analysis. It is possible to analyse the data from time series, which is the type of data collected from Fish Pool. What we aim to find is the volatility of the spot price. It is not possible to observe the volatility directly, which means that it must be estimated. It is possible to use the standard deviation on historical data, but this method has a major limitation because it puts equal weight on each observation. We will be using the *generalized autoregressive conditional heteroskedasticity* (GARCH) process, developed by Robert F. Engle in 1982 to describe an approach to estimate volatility in financial markets. This process provides a more realistic context when attempting to predict prices and rates of financial instruments (Engle, 1982).

The volatility in a market will swing up in periods of economic crisis and conversely, markets become less volatile in periods of calm economic growth. A simple economic model assumes homoskedasticity and often employ a basic ordinary least squares (OLS) regression. The goal of an OLS regression is to minimize the deviation between the data points to produce a regression line to fit this relationship as well as possible. In other words, it does not account for variation in volatility, which makes it suboptimal for predicting market behaviour through turbulent times. GARCH models on the other hand are excellent at describing financial markets with changing volatility because it assumes that heteroskedasticity is present. It also accounts for shocks to the price and gives a different weight to recent shocks compared to historical shocks. Serial correlation in quadratic returns (conditional heteroskedasticity) can be modelled as an autoregressive conditional heteroskedasticity (ARCH) model that follows

$$r_t = E_{t-1}(r_t) + \varepsilon_t \tag{5}$$

$$\varepsilon_t = z_t \sigma_t \tag{6}$$

$$\sigma_t{}^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}{}^2 + \ldots + \alpha_p \varepsilon_{t-1}{}^2 \tag{7}$$

Where r_t is the returns, ε denotes the shocks in the returns, E_{t-1} is an operator for expectations at t-1, $\sigma_t{}^2$ is the standard deviation (or variance) in logreturns, p is the number of delays and α is the coefficient for each of the shocks.

This model is insufficient for the purposes of this thesis. Because the spot price has seen excellent growth, it would be necessary to include an additional element to the model. By introducing a moving average, the standard deviation will be more "localized" and thus more accurate. Known as the *autoregressive moving average* (ARMA), the method was developed by (Bollerslev, 1986) and follows:

$$\sigma_t{}^2 = \omega + \sum_{i=t}^{p} \alpha_i \varepsilon_{t-1}{}^2 + \sum_{i=1}^{q} \beta_i \sigma_{t-i}{}^2 \tag{8}$$

Where ω is the long-term average of the variance, α denotes the parameters for the shocks in returns from lag 1 to p and tells us something about how much weight is put on price shocks. β is the parameter for lagged variance from 1 to q. This parameter describes what the lagged variance means to the conditional variance.

The general equation for an ARMA-GARCH model consists of three distinct parts. The first part is the long-term average that the volatility returns to after a shock (ω), then there is the ARCH that drives the process and finally there is a GARCH part (Misund, 2018).

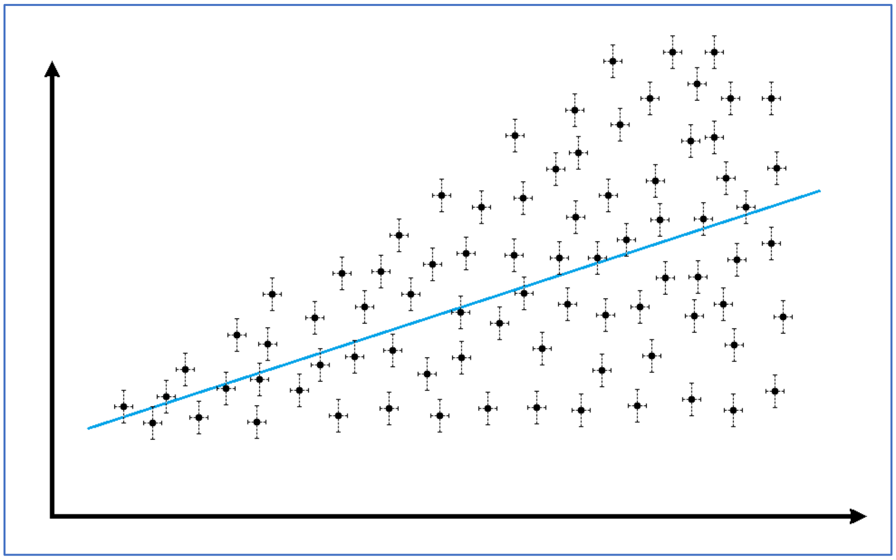

Figure 9 Variance increases over time

The GARCH process makes use of heteroskedasticity, which is a term that describes the situation where observations do not follow a linear pattern (see figure 9). Heteroskedastic observations tend to cluster and produce non-reliable predictions. The GARCH process is accounting for this, which increases the precision of forecasts.

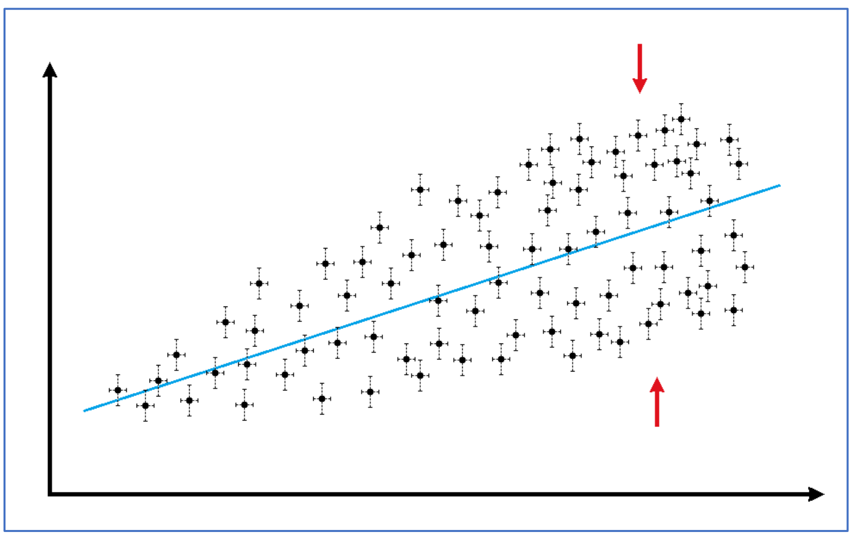

Figure 10 Variance is held more constant

Firstly, an AR(0) - GARCH(1,1) model was estimated, and then we took notes of the information criteria. We then added a lag and did the same thing until we had tested for ten lags, results are displayed in table 4. The information criteria suggested either use of zero or eight lags, which means that we have to use eight lags. The number of lags must exceed the fitted degrees of freedom. Eight lags could be excessive, but since it was suggested by AIC (which tries to find the true model) and SIC (tries to select the most formal model), it is reasonably grounded.

	AIC	BIC	SIC	HQIC
AR(x) - GARCH(1,1)				
AR(0)	-1,871114	**-1,787067**	-1,872687	**-1,83696**
AR(1)	-1,872869	-1,76781	-1,875304	-1,830176
AR(2)	-1,86563	-1,73956	-1,869107	-1,814399
AR(3)	-1,865227	-1,718145	-1,869917	-1,805458
AR(4)	-1,874796	-1,706702	-1,880868	-1,806487
AR(5)	-1,867612	-1,678507	-1,875231	-1,790765
AR(6)	-1,868322	-1,658205	-1,877648	-1,782937
AR(7)	-1,872431	-1,641302	-1,88362	-1,778507
AR(8)	**-1,886332**	-1,634191	**-1,899536**	-1,783869
AR(9)	-1,881661	-1,608508	-1,89703	-1,77066
AR(10)	-1,867507	-1,573343	-1,885186	-1,747968

Table 4 Smallest numbers are highlighted in bold.

The chosen model is the AR(8) – GARCH(1,1). The parameters of which are displayed in table 5. The statistical insignificance of the parameters seems to suggest that the model is poor. The statistically least insignificant are μ, AR(3), AR(4), AR(6) and AR(8). $\beta_1$is statistically significant in the variance function.

	Estimate	Std, Error	t value	Pr(>|t|)
ARMA(8) (Price function)				
μ	0,0119751	0,0077917	1,537	0,124
AR(1)	0,0888783	0,0802541	1,107	0,268
AR(2)	-0,0251604	0,0857629	-0,293	0,769
AR(3)	-0,1681601	0,1130915	-1,487	0,137
AR(4)	-0,1190033	0,0813538	-1,463	0,144
AR(5)	-0,0675793	0,0799322	-0,845	0,398
AR(6)	-0,1396071	0,0880703	-1,585	0,113
AR(7)	-0,0874580	0,0848866	-1,030	0,303
AR(8)	-0,1334155	0,0934981	-1,427	0,154
GARCH(1,1) (variance function)				
ω	0,0012840	0,0008485	1,513	0,130
α_1	0,0697773	0,1072214	0,651	0,515
β_1	0,7677138	0,1077486	7,125	1,04e-12 ***

Table 5 Results from model estimation. [11]

After estimating the GARCH(1,1) model, a series of diagnostic tests on the residuals will be conducted. These will test for homoskedasticity, serial correlation, the presence of ARCH-effects not captured by the model and one to determine whether a GARCH model is relevant.

Standardized diagnostic tests on the residuals:	
Jarque-Bera, **Shapiro-Wilk**	*If the null hypothesis of homoskedasticity is rejected, the standard errors must be made robust.*
LM-ARCH test (Engle, 1982)	*Used to determine whether a GARCH model is relevant.*
Ljung-Box, Li-Mak	*Sees if there are ARCH- effects not captured by the model. The null hypothesis is the absence of ARCH effects.*
Ljung-Box	*Test for serial correlation. The null hypothesis is the absence of serial correlation in the standardized error terms.*

Table 6 Standardized diagnostic tests on the GARCH residuals.

[11] Notice only beta 1 is statistically significant. *** = significant at <99%.

This is relevant because we need to know the properties of the data in order to say something meaningful about the nature of the model. The results are displayed in table 7.

			Statistic	p-value
Jarque-Bera Test	R	Chi^2	3,798158	0,1497064
Shapiro-Wilk Test	R	W	0,9841732	0,1063876
Ljung-Box Test	R	Q(10)	2,795623	0,9858329
Ljung-Box Test	R	Q(15)	25,30685	4,60E-02
Ljung-Box Test	R	Q(20)	38,55228	7,58E-03
Ljung-Box Test	R^2	Q(10)	10,20334	0,4228381
Ljung-Box Test	R^2	Q(15)	16,29623	0,3626418
Ljung-Box Test	R^2	Q(20)	23,50422	0,2647192
LM Arch Test	R	TR^2	10,52908	0,5696478

Table 7 Test results on the residuals.

What the diagnostic tests tells us is that the standard errors are homoscedastic, which means that no action needs to be taken to correct for this. The standard errors do not need to be made robust. The Ljung-Box test found ARCH-effects that are not captured by the model, in Q(15) and Q(20). These are highly statistically significant. This is to be expected.

The data will also need to be tested for stationarity. This needs to be conducted in order to see whether or not the mean, variance, autocorrelation etc. of a time series, remain constant over time. This will reveal the nature of the stationarity, if any, and perhaps help in projecting values for the future movements of the variables. We will rely on a Dickey-Fuller test for this, and test the spot price, logreturns and the annualized volatility estimated by an AR(8)-GARCH(1,1) model.

3.2.3 Dickey-Fuller test

The augmented Dickey-Fuller test (ADF) that we will use tests for the presence of a unit root in a time series sample. The ADF test assumes

$$\Delta Y_t = \alpha + \beta t + [\varphi - 1]Y_{t-1} + \tau\Delta Y_{t-1} + \omega \tag{9}$$

where we want to see whether if $\varphi = 1$. If this is the case, then we reject the null hypothesis that there is a unit root, and accept the alternative hypothesis that the variance, mean etc. is stationary. The values we are interested in are displayed in RStudio as the test statistics. If the statistics exceed the values in table 8, then we are unable to reject the null hypothesis and we can assume that the series is non-stationary.

	99%	95%	90%
Critical value	-2,575829	-1,959964	-1,644854

Table 8 Critical values to compare test statistics.

The augmented Dickey-Fuller test tests for the presence of a unit root in a time series sample. The null hypothesis is that there are unit roots present in the data, while the alternative hypothesis is that the variance and mean in the time series is stationary. First, we tested without including intercept or trend (table 9). Then we added an intercept, and finally also a trend, all with eight lags.

Test	Without drift and constant	With drift	With trend
SpotPrice	1,0837	-1,7526	-3,5951**
LogReturns	-6,9928***	-7,0408***	-7,0132***
Volatility	0,1619	-3,5985***	-3,9012**

Table 9 Critical values for test statistics from the Dickey-Fuller test. [12]

[12] Note to table 9: *** : 99% , ** : 95% , * : 90%

We can see that the spot price is trend-stationary, which is interesting, but the returns are stationary as expected. The volatility is also trend-stationary; however, at the 5% significance level.

3.2.4 Johansen tests

Cointegration is a statistical property of a collection of time series. This collection is cointegrated if all the time series is integrated of order one, I(1), and a linear combination is integrated of order zero, I(0) (Sørensen, 2005). If we have nonstationary time series, it is not recommended to regress them on each other. So in order to examine how these are cointegrated, consider figure 11, where y_t is I(1) and x_t is I(1), then we can find a β. If we multiply x_t by β then we will essentially "rotate" x_t and this will make the difference between the two time series relatively constant. In other words, this scaling factor will even out the distance between y_t and x_t. An augmented Dickey-fuller test is unable to check more than two time series at a time; thus we need a different test. The Johansen permits use of more than two time series. There are two slightly different types of Johansen test, but we will only use one. This uses trace (sum of the elements of the main diagonal in a matrix). The null hypothesis is that the number of cointegration vectors is $r = r^* < k$ and the alternative hypothesis is that $r = k$.

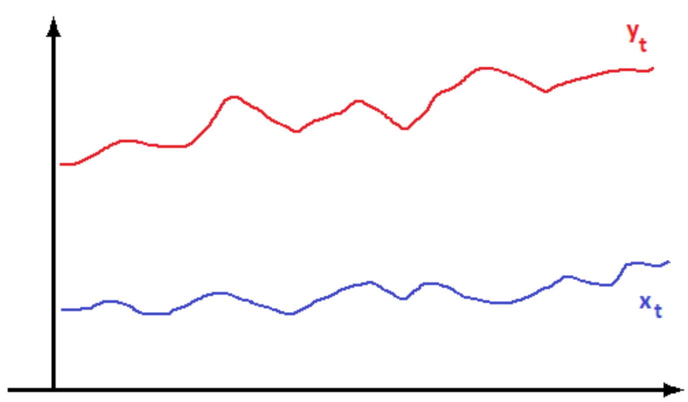

Figure 11 Cointegration of two time series.

3.2.5 Flow of goods and information

As specified in chapter 2.2.1 a contract needs free flow of information and goods in order to succeed. We will investigate this by discussing the flow of goods and information separately.

3.2.6 Vertical integration

When enough participants in a market get control of more than two chains in the supply chain it can become a problem, as outlined in chapter 2.2.1. A discussion about this will be conducted by studying how many of the players in the market are vertically integrated.

3.3 Factors related to the actual contract

When it comes to the actual contract there are several factors that are relevant for study. In order to determine whether the contract from Fish Pool itself is succeeding, we need to study three main prerequisites. A successful contract does not need to oblige by all of these prerequisites, but all of them contribute towards the success of a futures contract.

3.3.1 Attractiveness to the hedgers

The contract needs to attract sellers and buyers of salmon who seek to limit their exposure to price risk. It needs to provide sufficient security in the sense that there are mechanisms in place to compensate a party if a contract is not fulfilled and follow a standardized template. In addition, the contract must provide security against fluctuations in the spot market. We will discuss how attractive the contract is to potential hedgers, followed up by an analysis of the backbone of the contract, namely three weight classes of salmon, by conducting a Johansen test on the salmon classes, as outlined in chapter 3.2.4. The Johansen test on the three weight classes used in the Fish Pool Index returned the values presented in table 10.

	test	10 %	5 %	1 %
r <= 2	8,93	6,5	8,18	11,65
r <= 1	36,27	15,66	17,95	23,52
r = 0	92,21	28,71	31,52	37,22

Table 10 Johansen test on 3-4 kg, 4-5 kg and 5-6 kg of salmon used in FPI. [13]

For $r = 0$ we can see that the test statistic (92,21) is larger than any of the percentiles which means that we can, with more than 99% confidence say that there is one stationary combination of the salmon classes 3-4 kg, 4-5 kg and 5-6 kg. These are highly correlated (table 11), which makes it no surprise that there exists a cointegrated relationship.

	3-4 kg	4-5 kg	5-6 kg
3-4 kg	1.0000		
4-5 kg	0.9967*	1.0000	
5-6 kg	0.9834*	0.9938*	1.0000

Table 11 Correlation between3-4 kg, 4-5 kg and 5-6 kg. [14]

This means that the index is based on a highly correlated portfolio of fish classes. This makes the index vulnerable to fluctuations in the prices of these assets but a good indicator of the spot price.

[13] Data collected from the Nasdaq Salmon Index (NSQ).

[14] Note to table: A star indicates a significance level of 99%. Data collected from Nasdaq Salmon Index.

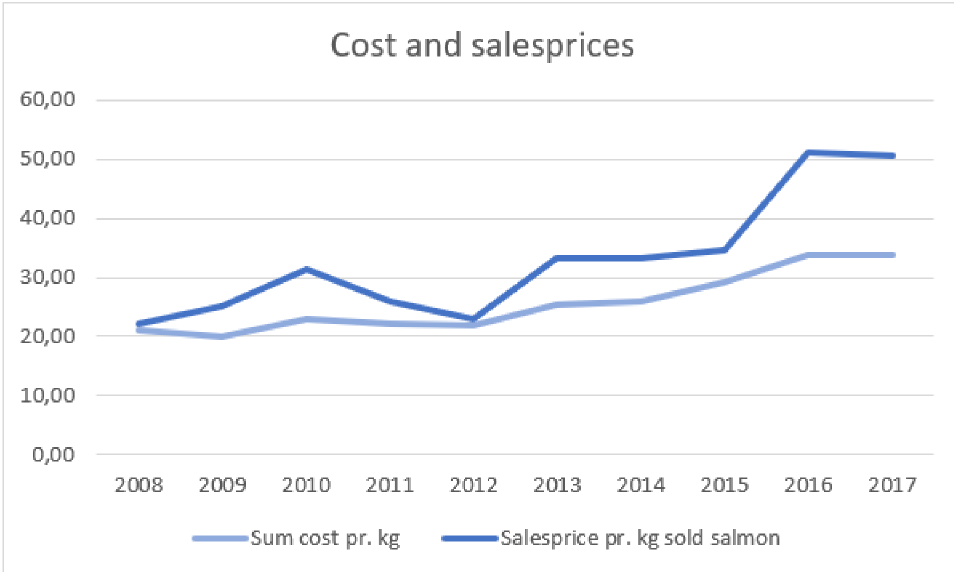

Figure 12 Cost and sales price. [15]

The farmers in the simplest of terms need to balance their income and expenses. Figure 12 displays the estimated cost per kg produced fish of all types in Norway and the estimated sales price for salmon. It should be noted that the cost structure of salmon may differ from other types of fish, but the conclusion is nevertheless the same; fish farmers have a good margin to absorb fluctuations in the sales price. This is best represented in the operating margin (figure 13), which tells us that it has increased drastically during the period we have studied.

[15] Source: Norwegian Directorate of Fisheries.

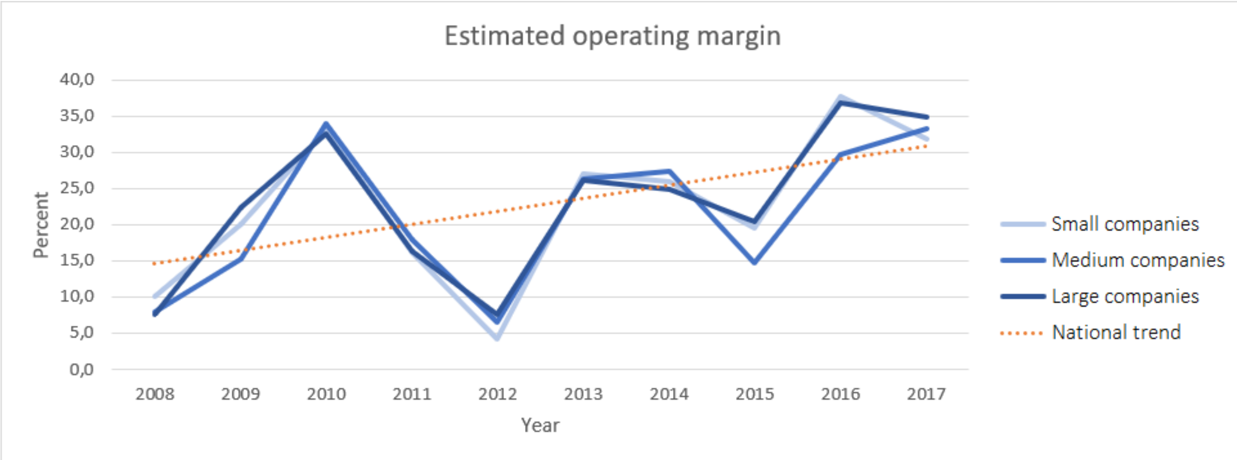

Figure 13 Estimated operating margin. [16]

The relatively high numbers in 2010 was caused by low production quantities that inflated the salmon price. The low numbers in 2012 was caused by a severe drop in the spot price and in 2015 it was caused by a dramatic termination of salmon stock on the grounds of lice infestations. One important note is that termination of stock represents significant economic losses which are not included in this estimation.

3.3.2 Attractiveness to speculators

The market needs to be of a sufficient size and be liquid enough to attract speculators, many of whom may be discouraged from investing if the contract is not liquid enough. This will be studied by calculating the liquidity of the contracts. We will indulge in a discussion about how attractive the contract is for potential speculators, followed up by an analysis of the liquidity of the contract.

3.3.3 Flexibility versus vulnerability to manipulation

The contract requires some degree of flexibility while remaining difficult to manipulate. We will discuss the flexibility by examining the grading system. To see whether the contract is easy to manipulate or not, we support our findings on previous literature and study the contract design.

[16] Source: Norwegian Directorate of Fisheries.

3.4 Factors related to other futures contracts

To be able to say something about how the salmon compares with other commodities, we will look at the correlation with other commodities and study them through a Johansen test for cointegration. The Johansen test is a more generalized multivariate version of a Dickey-Fuller test. The reasoning behind the decision to go for a full cointegration test on all the chosen commodities is to illustrate the difficulty in developing a good hedging ratio. As stated previously, the problem with other tests is that they cannot create β regression parameters (hedge ratio) for more than two separate time series at a time. Information about correlation, covariance and cointegration will reveal important information about how salmon contracts performs in relation to other commodity contracts. The critical values from a Johansen test on a portfolio consisting of salmon, shrimp, poultry, lamb, corn and soybeans are displayed in table 12. The spot prices of salmon, shrimp, poultry, lamb, corn and soybeans was collected from quandl.com.

	test	10pct	5pct	1pct
r <= 5	0,2	6,5	8,18	11,65
r <= 4	7,43	15,66	17,95	23,52
r <= 3	15,19	28,71	31,52	37,22
r <= 2	28,29	45,23	48,28	55,43
r <= 1	60,34	66,49	70,6	78,87
r = 0	97,53	85,18	90,39	104,2

Table 12 Values of test statistic and critical values of test

We can see that r = 0 gives us a test stat of 97,53 which is larger than 90,39 from the 5% confidence level. From this we can claim with 95% confidence that there is a stationary combination between the six commodities we looked at.

	Salmon	*Shrimp*	*Poultry*	*Lamb*	*Corn*	*Soybeans*
Salmon	1					
Shrimp	0.1100	1				
Poultry	0.0700	0.0400	1			
Lamb	0.17*	0.18**	0.18**	1		
Corn	0.18**	0.0300	-0.0100	0.16*	1	
Soybeans	0.23***	0.0700	0.0300	0.22**	0.71***	1

Table 13 Correlation with spot price of other commodities [17]

The low correlation between salmon and other commodities is evident in table 13. The highest correlated commodity is soybeans, which is used in the fish food but 23% does not make for a strong correlation. Our findings are on accord with previous literature *(Bergfjord, 2007)*.

	Salmon	*Shrimp*	*Poultry*	*Lamb*	*Corn*	*Soybeans*
Salmon	53.6510					
Shrimp	4.2589	29.2140				
Poultry	0.8330	0.3290	2.4998			
Lamb	4.0113	3.1325	0.9409	10.4699		
Corn	8.6263	1.1252	-0.1123	3.5256	44.1953	
Soybeans	10.4754	2.3820	0.2978	4.5213	29.2748	38.5989

Table 14 Covariance with the spot price of other commodities

The covariance matrix (table 14) reveals the same relationship as the correlation matrix. The strongest covariation with salmon is, as expected with soybeans.

[17] Note to table: Significance levels: * = 0,1 ** = 0,05 *** = 0,01

3.5 Factors related to the exchange and its users

The final research question will elaborate on the exchange itself, studying the geographical location and digital presence, in addition to the finances of the exchange as a company. It will also look at the users of the contract and try to make clear who is using it. For this we will study the annual reports for Fish Pool, as there is little information regarding the traders published elsewhere.

3.6 Conclusion

A simple answer to the research problem will not suffice because there are many different factors that affect an exchange such as Fish Pool. While the contract may fulfil the prerequisites of one success factor, it may fail completely on another. Studying the different factors individually with the methods mentioned in the above chapters will produce enough information to conclude the thesis. We will use our findings and gauge the success of the contract according equation 1.

4.0 Results and Discussion

The following chapter will consist of a discussion of the results and findings from the previous chapter.

4.1 Factors related to the underlying market

In this subchapter, we will go through the conditions of the underlying market, and discuss the volatility, homogeneity, the effect of storability, transparency and vertical integration.

4.1.1 Volatility

The underlying market for salmon is characterized by a high and increasing volatility (Misund, 2018). High volatility can raise the need for price securing instruments. While this may be attractive for speculators, it seems that it is too risky for many, discouraging new investments. The results from the GARCH method returned volatility that we have plotted in figure 14.

Figure 14 Annualized volatility from model. [18]

In the graph below (figure 15), created with RStudio, the historical spot price is marked as data. Looking at the data for the spot price of salmon, it has more than doubled during the period, changing from 24,54 NOK per kilo in September 2009 to 69,45 in March 2019. The spot price

[18] Notice the y-axis starts at 20%.

has been quite volatile and have, during this period, both gone above and below these numbers. The lowest is 20,64 NOK in October 2011, while the highest price were 76,02 NOK in May 2018. The spot prices show an increasing trend. The seasonal effects are generated by RStudio and the trendline is derived from the spot prices, while the remainder is the residual from the seasonal plus trend fit.

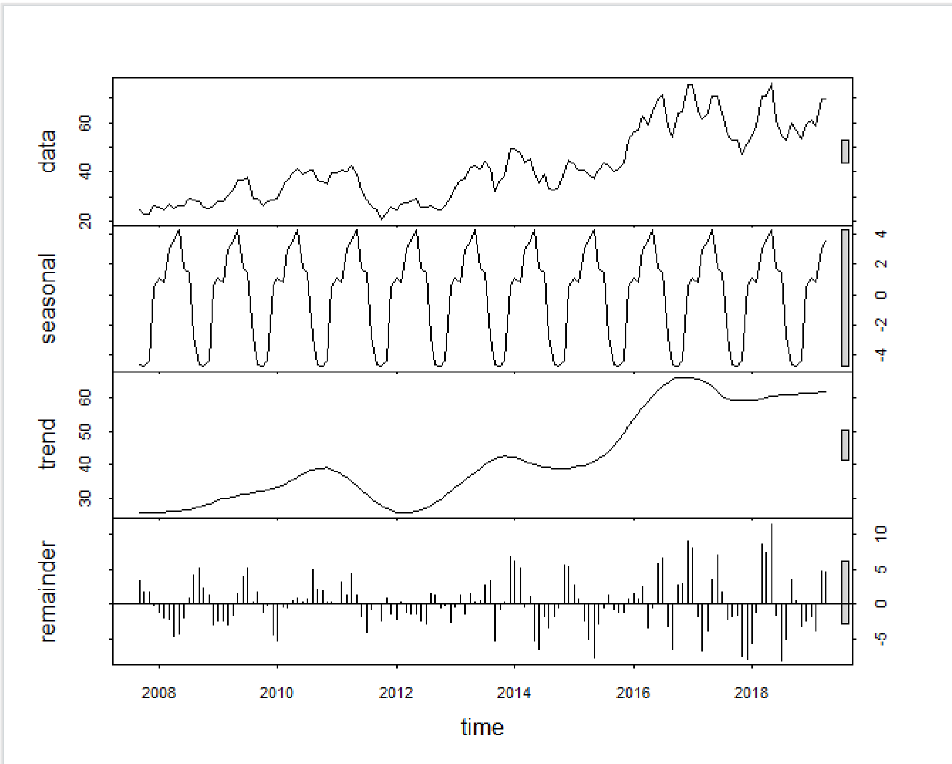

Figure 15 STL decomposition of the spot price.

While standard deviation is useful for studying volatility, it is not a particularly well-suited method of study for our purposes. Return on investment is a much more appropriate analysis method in this context, following the general form:

$$ROI_t = \frac{Current\ Value_t - Beginning\ Value_{t-1}}{Beginning\ Value_{t-1}} \cdot 100 \tag{10}$$

Equation 10 will give the change in percent from the previous week and gives a better picture of the volatile nature of salmon spot price. Figure 16 is an excerpt from January 2018 through December 2018 and shows how much the price can change from one week to the next.

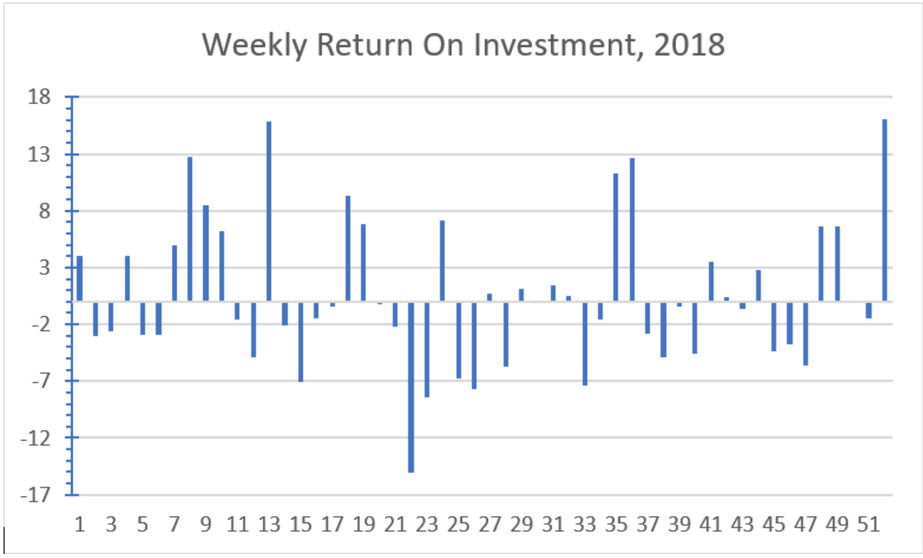

Figure 16 Return on investment per cent.[19]

It is easy to notice how the spot price changes with great magnitude in this period. The same is true across the entirety of the dataset, with most of the weekly changes happening around 5-10%. This can become an issue for hedgers and speculators with a low threshold for risk and discourage them from investing in this market.

Judging by the P-values in table 5, none of the lags are statistically significant in the pricing model. The base level for volatility, ω is $1{,}284 \cdot 10^{-3}$. This is given as variance and gives us an annual volatility of 12,41%, which is a little lower than the standard deviation we found in table 8, however this coefficient is not statistically significant. A logical conclusion to draw would be that there is no long-term average for the volatility uncovered by our model.

[19] Source: Quandl, weekly data

The sum of α and β is a way of measure the duration of our volatility, and in effect the market efficient. If this sum is larger than 1, it means that the market is under a regime of opposition to shocks. We found *0,0698+0,7677 = 0,8375* which indicates that the salmon market needs a relatively long time to return to the eventual long-term average. This results in a long time to correct for shocks in the salmon price. This is consistent with previous literature (Misund, 2018; Oglend, 2013). The results are also clear on that the volatility is high and follows an increasing trend. Our AR(8) – GARCH(1,1) model only returned one statistically significant coefficient, which is the β_1. The fact that only one of the coefficients is statistically significant means that this result should be taken with a grain of salt.

The half-life K is the time it takes to close the gap between the conditional variance and the long-term average. We found this to be almost four months (equation 11). This seems like a relatively low number when compared with previous work; however, we are studying a much smaller time series than what is studied in previously cited literature. In addition to this, we were unable to extract a statistically significant long-term average for the volatility.

$$K = \frac{ln(0{,}5)}{ln(\alpha + \beta)} = 3{,}9085 \tag{11}$$

Figure 17 shows the STL decomposition of the volatility. There are some grey columns on the right side of the graphs, which indicate the importance of their respective components. They tell us that the most important component in determining the volatility is the trend component. It is characterized as increasing in a wave-like pattern, alternating between periods of relatively high and relatively low price uncertainty. There is also a seasonal component, which generally can be described as the recurring trends in the market but is largely unimportant, judging by the y-axis. The same goes for the residual component, because its importance is just slightly higher than the seasonal component. One thing to note is that the residuals seem to manifest in clusters because one is rarely observed alone, especially with greater magnitudes. This reveals the existence of elements that is not captured in our AR-GARCH model, which could be changed or altered.

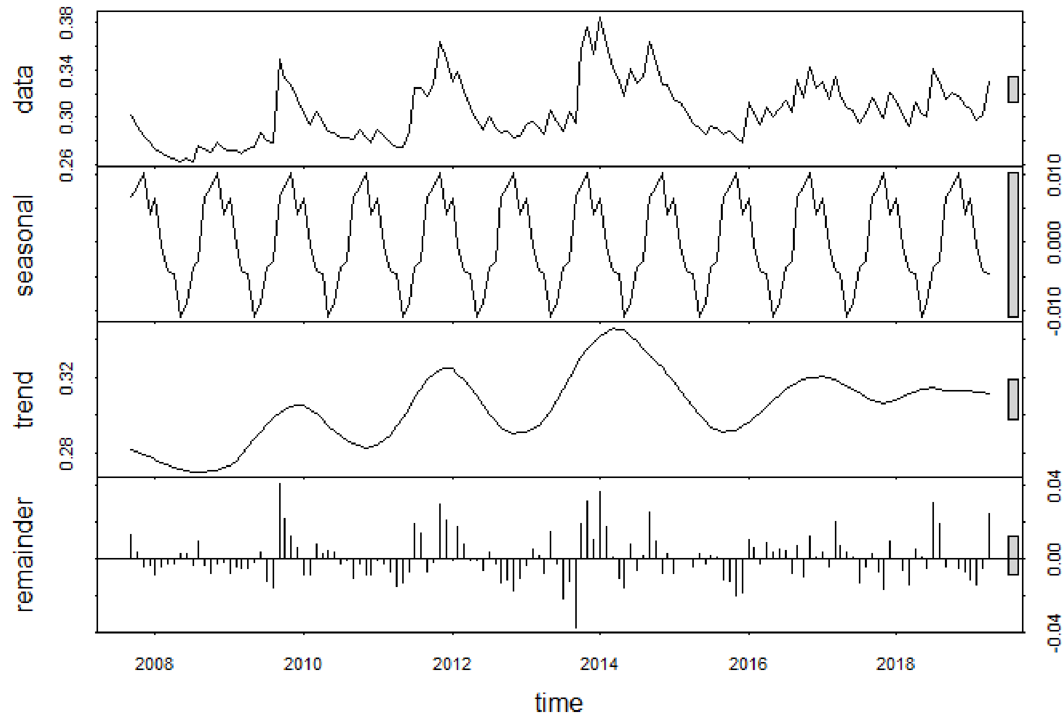

Figure 17 STL decomposition of the volatility into season, trend and residuals. [20]

Since the trend in spot price volatility is not constant, one concern is that it is non-stationary. It could, however, be trend stationary. To see whether it is or is not, we will conduct an augmented Dickey-Fuller test on the spot price, the results of which is displayed in table 9. The existence of a unit root in the time series is evident in the mostly negative values of τ, which means that the volatility is not stationary. It is instead trend-stationary, with a confidence of 95%. Logreturns are statistically significant in all regards. This is consistent with the observations we did in graph 17.

To summarize, the analysis shows that the volatility is high and increasing. It seems like there could be ways to predict when it becomes high or low based on how evenly the “waves” are spaced out. The presence of unit roots shows that the volatility is stationary with the trend, which is increasing. This *could* discourage investors from using salmon contracts to either hedge their

[20] Data represents the volatility estimated by an AR(8) – GARCH(1,1).

profits or speculate for a profit. The trend seems however, to stabilize on a relatively high value from 2016 and onward. This could just be a temporary period of stable price uncertainty but judging by the trend stationary nature of the trend component in figure 17 it seems unlikely it will last for long.

4.1.2 Homogeneity

Salmon is a commodity that is possible to grade into size classes. Fish Pool uses the same weight classes as Nasdaq to produce the Fish Pool Index, which is based on a weighted weekly average of the 3-6 kg classes of gutted fish with head and of superior quality. This tells us that the market grades the fish in a generally homogenous manner. When it comes to storability, it is possible to freeze salmon to keep it from spoiling, thus prolonging the window for sales. This is evident in the sold quantities fresh or cooled salmon and frozen salmon (see figure 18). By doing so, some quality is lost however, in comparison to fresh salmon.

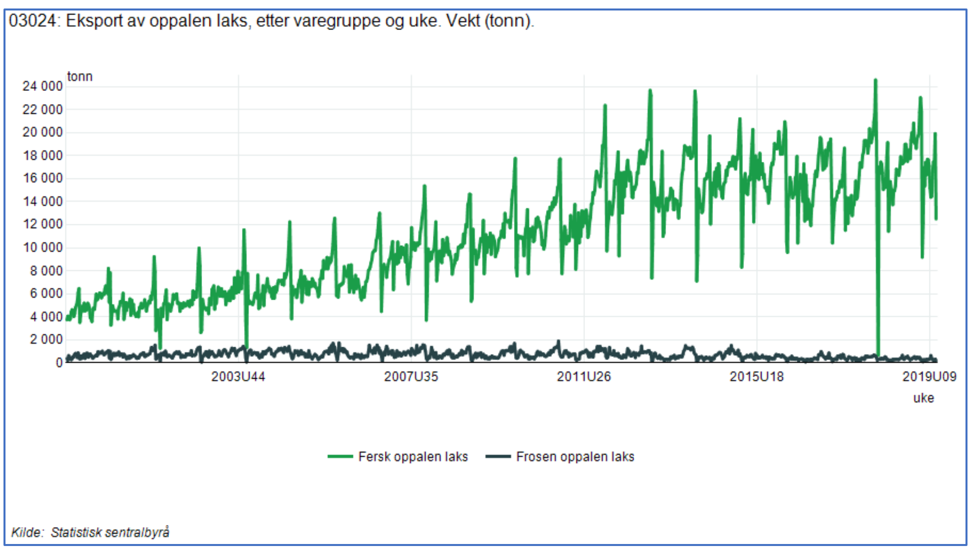

Figure 18 Exported farmed salmon in frozen or fresh state.[21]

Information and transparency are also an important factor for the underlying market. Information regarding the price of salmon is available for everyone from the Fish Pool Index. Free flow of goods is also worth a mention in a discussion about export, but it is not a large issue

[21] Note to figure 18: Green graph is fresh salmon and black is frozen salmon.

domestically. Based on the underlying market, it would appear that there is room for Fish Pool to be successful at limiting risk exposure in the spot market.

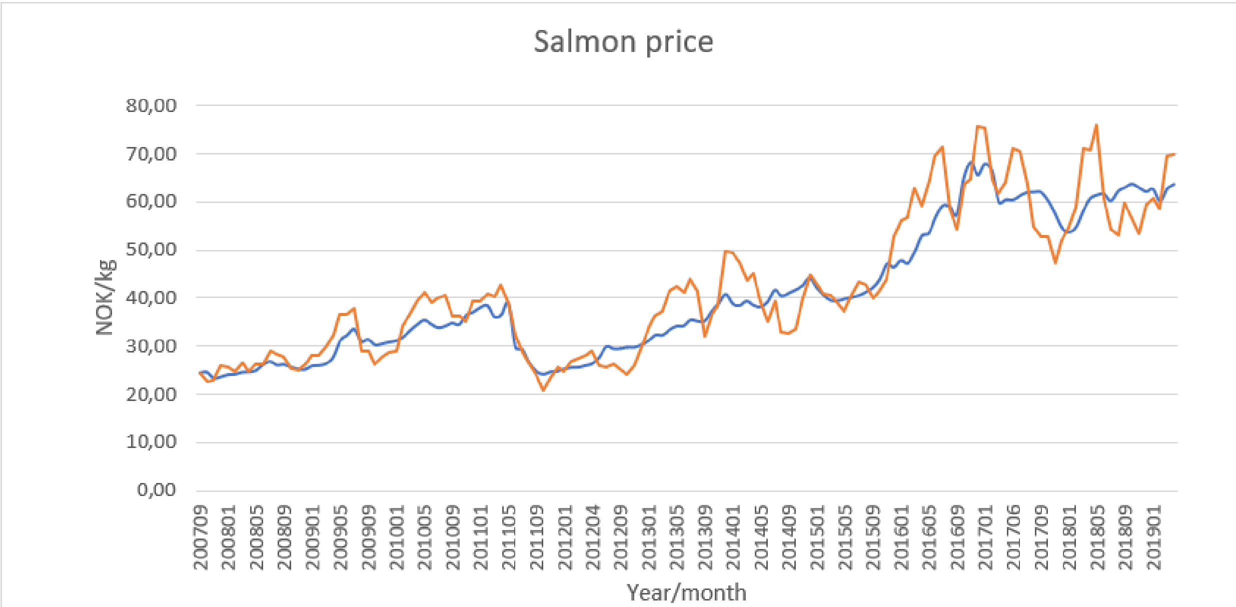

Figure 19 Spot price versus weighted average price for salmon. [22]

The trading at Fish Pool has varied over time, both in numbers of trades and the amount of salmon traded. January 2011 holds the largest amount of salmon sold; 28 trading's and 23799,95 tons sold. The least liquid month were July 2012 with one trading and 300 tons of salmon traded in a single transaction.

[22] Note to figure: Orange line is the spot price and blue is the weighted average monthly contract price. Notice that the spot price is more volatile than the futures contract price.

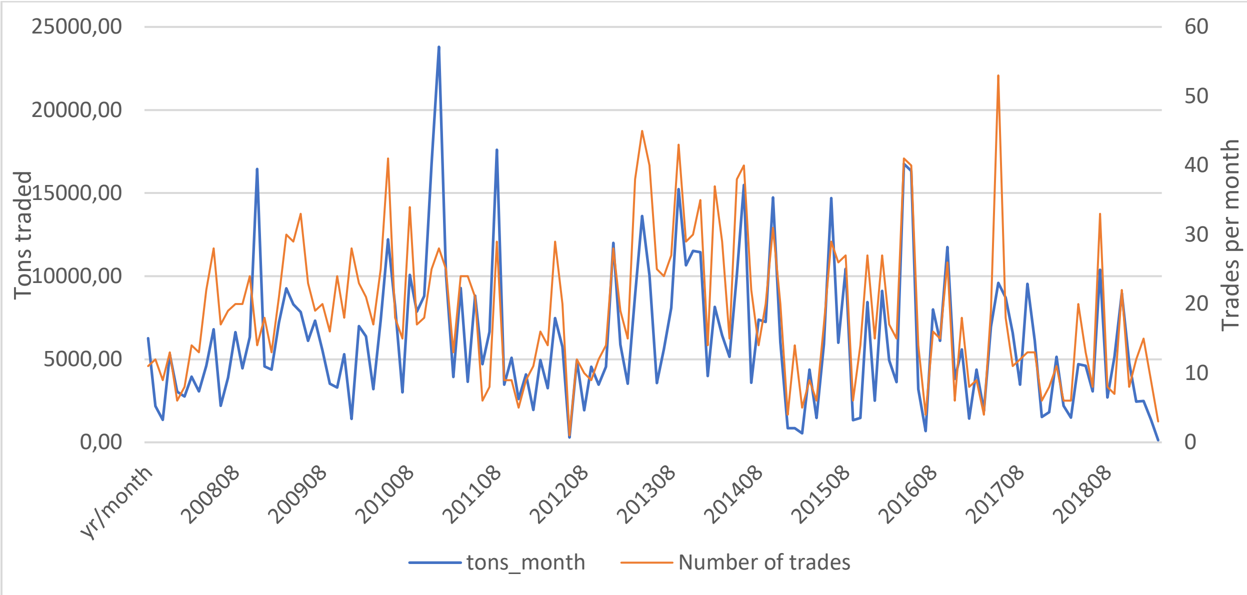

Figure 20 Tons and number of trades per month.

4.1.3 Vertical integration

The presence of vertical integration in the spot market makes it harder for a futures contract to succeed. Bergfjord (2007) stresses the matter that there are large companies in the salmon market, where the production is concentrated. In 2006, Bergfjord conducted a survey on Norwegian fish farmers and their thoughts about risk and risk management. Out of the 38 responding fish farming companies, 21 of the respondents viewed themselves as either large concerns or companies that controlled two or more links of the value chain (Bergfjord, 2006). This data is from 2006; however, this seem to still be the case in today's market. More recent work concludes that the number of companies that produce 80% of the biomass has decreased while the total production has increased (Asche, Roll, Sandvold, Sørvig, & Zhang, 2013). The degree of vertically integrated companies seems to be increasing.

There are several large companies in the salmon market, that are both vertically and horizontally integrated. These participate in several parts of the value chain; from producing food for the salmon, hatching of smolt, actual farming and the processing of the fish. Companies such as these remove several pricing points and thus the accompanying risk. Smaller companies will presumably seek the income security provided by the umbrella of a larger company, as they are more vulnerable to changes in the commodity price. This is on accord with previous work (Misund, Martens, Nyrud, & Dreyer, 2018).

Big companies that controls several parts of the value chain is becoming more prevalent in the salmon market and this reduces the demand for futures contracts. It also makes it easier to manipulate the market, which can potentially discourage speculators from trading. This makes vertical integration in the salmon market a potential threat against success for a futures contract and a topic of concern.

4.2 Actual contract

Successful futures contracts may rely on market characteristics to survive, but the design is also important. It needs to attract hedgers, speculators and arbitrageurs alike. Successful contracts have large potentials for decreasing the risk in an otherwise volatile market. This chapter will discuss how well the contract at Fish Pool performs in these regards and conclude based on a holistic assessment.

4.2.1 Is the contract attractive to hedgers?

Hedgers look for high hedging effectiveness in a contract. It is intuitively designed in such a way that the information is easy to extract. One contract is for one metric ton of fresh salmon of a certain grade to be purchased or sold at a specific point in the future. If the contract in its entirety, or is partly defaulted, there are mechanisms in place to compensate the affected party. The sense of security such a contract provides the parties with is key for attracting hedgers. These contracts have a standardized design to make it easy for traders to keep track of their trades, especially if they are trading with several, highly diversified portfolios. Fish Pool provides contracts that have content listed below in table 15.

- ❖ The contract is measured in the metric system.
- ❖ How the trade is going to be settled. Fish Pool does not provide delivery of the fish.
- ❖ One single contract is for one metric ton of salmon.
- ❖ The currency unit in which the contract is denominated is the Norwegian Krone (NOK).
- ❖ The contract is quoted in the Norwegian Krone (NOK).
- ❖ The grade of salmon and size classification.

  The fish is divided into nine categories as listed below, however the FPI is based on a weighted weekly average of the sizes 3-6 kg of gutted fish with head, and superior quality.

  - ➢ 1-2 kg
  - ➢ 2-3 kg
  - ➢ 3-4 kg
  - ➢ 4-5 kg
  - ➢ 5-6 kg
  - ➢ 6-7 kg
  - ➢ 7-8 kg
  - ➢ 8-9 kg
  - ➢ 9+ kg

Table 15 Content of the Fish Pool futures contract

The delivery price based on a weekly average of salmon and this makes it less exposed to manipulation. What makes this interesting, is that the number of trades is so low, which means that the market is small. Such a thin market with relatively few sellers and buyers is more prone to manipulation because it is cheaper for the investors to push up the prices just prior to the delivery (Bergfjord, 2007). This could reduce the credibility of Fish Pool and may discourage some economic activity. The contract price is based on the Fish Pool Index, which is partly based on three different elements. These are the SSB custom statistics (5%), Fish Pool European Buyers Index (10%) and the Nasdaq Salmon Index (85%). This in turn is based on the weekly average of the sizes 3-6 kg with three main size categories, namely 3-4 kg, 4-5 kg and 5-6 kg (as seen in equations 3 and 4.

Bergfjord (2009) found that only a minority of the farmers claimed that they were able to outperform the market. Since the primary motivation for a farmer is to reduce price risk, the expected value for hedging should be negative. He claims that most farmers are indifferent to the futures market and the ones that welcome it, does so with profits as the main motivation. He also found that many fish farmers who used the futures market did so essentially to reduce the risk at the cost of some profits.

The farmers enjoy low production costs and high sales price for salmon. This gives them quite a bit of leeway in the profit department and this results in a low demand for contracts aimed at hedging.

4.2.2 Is the contract attractive to speculators?

This is a subject that requires a more empirical form of analysis. One way of doing this is by measuring the liquidity, as many speculators do to consider assets of interest. In chapter 2.3 we laid out the groundwork for two different models for liquidity.

The market in which Fish Pool operates is very large in comparison to the amount of fish traded in the exchange. From our findings, the amount of salmon traded at Fish Pool generally lies somewhere between *4 - 11%* of the national salmon sales (figure 21), trending downward ending on ca 4,8% in 2017. One explanation for this is that the market grows faster while trading at Fish Pool is decreasing.

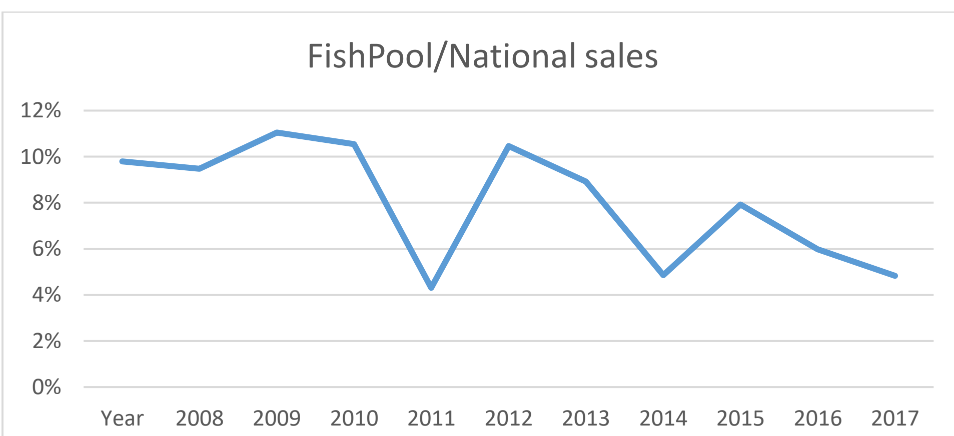

Figure 21 Share of traded salmon at Fish to the national Norwegian salmon sales.

The largest group of trade members are producers, which means that there could be an impairment in the bid/offer liquidity. This is difficult to claim with a high degree of confidence, as information about the trade members become limited after Nasdaq took over as clearing house in 2014 (Fish Pool, 2015). As speculators generally are attracted to markets with high volatility, one would think that the salmon market also is attractive, as the findings in 4.1 prove that the volatility is rather high. The question we are posed with then, is whether it is too high.

Bergfjord (2009) speculated that, if the speculators suspected the farmers possessed enough "insider" knowledge to outperform the market, then the speculators would pull out. This could be the case as the amount of salmon traded on Fish Pool is rather small compared to the total national market. Based on these findings, the contract seems to be suffering from a lack of liquidity, which makes it unattractive to speculative traders.

4.2.3 Is the contract flexible and hard to manipulate?

Flexibility of the contract is the most advantageous for the sellers of salmon and attracts most of the hedgers on this side of the contract. As seen in table 15 there is an extensive grading system for salmon. This means that the seller is prevented from destroying the market, as found by previous work (Tashjian & McConnell, 1989; Martinez-Garmendia & Anderson, 1999; Thompson, Garcia & Wildman, 1996; Sander & Manfredo, 2002). While a contract should be detailed, it should not be too detailed either. The grading system provides a decent platform to make sure that buyers pay for the grade of salmon that they can get, thus reducing the incentives for underbidding the contracts and the sellers only get a small window of opportunity to deliver a grade at a “too good” price. The Johansen procedure conducted in chapter 3.3.1 returned one cointegrated relationship between the highly correlated classes (table 10). The high correlation tells us that it is unnecessary to include more classes of fish to create a wider range. This means that the contract price is very hard to manipulate for one single actor on his own.

To summarize:

1. The contract is not attractive to hedgers.
   The hedgers are risk-tolerant and enjoy good operating margins. This results in a low demand for futures contracts.
2. The contract is not attractive to speculators.
   The contract has too low liquidity for attracting enough speculative trade.
3. The contract is slightly flexible and hard to manipulate.
   The contract is priced on the basis of products in the market which is too large for an actor to manipulate on his own.

We found that the contract is not attractive to neither hedgers nor speculators. The market is large enough to prevent easy manipulation of the contract which makes its robustness satisfactory in this context.

4.3 Other contracts

When it comes to other contracts, a futures contract is more likely to succeed if there are no futures contract for a close substitute. Bergfjord (2007) found that salmon prices had little correlations with the prices of other commodities. This could open a demand in the market for salmon futures contracts, making it possible for salmon futures contracts to succeed. The other commodities have good pre-existing hedges however, and the demand for a new hedge with poorer hedging qualities is thus rather superfluous.

The poor correlation and covariance with other commodities make it more complicated to establish a stable hedging relationship (see table 13). Salmon is most correlated with corn and soybeans, which makes sense as much of the fish food is made from this; and lamb. Bergfjord (2007) found that few salmon farmers or producers use futures contracts on other products to hedge against the price risk linked to their product. This seems like a missed opportunity;

however, the production of salmon is complex to such a degree that it is difficult to single out specific input factors.

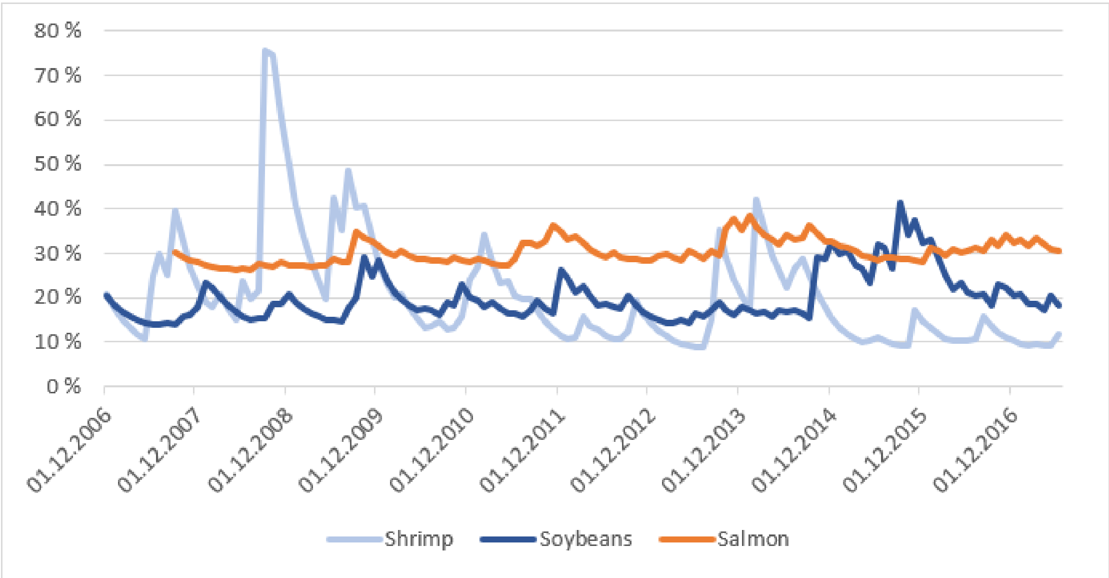

Figure 22 Volatility of soybeans, shrimp and salmon.

Comparing the logreturns of salmon, soybeans and shrimp, the most highly correlated commodities we studied, it appears that salmon has a high, but comparatively constant price uncertainty (figure 22). Soybeans, which can be considered a success in the futures market, have in general a lower variation in the prices, but has periods of higher volatility than salmon. Soybean farmers look at very tight operating margins, with the estimated cost per bushel (27,2 kg at 13% moisture (North Dakota State University, 2019) of soybeans in Illinois ranged from $9,63 to $11,41 in 2018 (Krapf, Raab, & Zwilling, 2018). In the same period the price per bushel ranged from $8,19 to $10,714 1 (macrotrends.net, 2019). Thus, it is clear that the producers of soybeans are much more vulnerable to fluctuations in the spot price, which creates a strong demand for price securing instruments. Looking at shrimp, which has been considered a failure in the futures market, has big variation, with periods of big fluctuation. The producers in China have enjoyed a fairly good margin ratio of 47% (Mansaray, Hayford, Jing, Lin, & Xinhua, 2018). Other work has also found similar results on inland shrimp farming (Sanders & Manfredo, 2002). It seems like there is a connection with the operating margins and success of futures contracts.

4.4 The exchange introducing the contract and its users

This subchapter will discuss the exchange itself and its users. The exchange will be discussed along the lines of location, size and financial condition. We will also discuss the effects caused by Nasdaq. The users will be broken down into segments and discussed separately.

4.4.1 The exchange

As previously mentioned, futures contracts are sold on exchanges such as Fish Pool. A large portion of the traded futures contracts consists of commodities such as pork bellies, oil and, in the context of this thesis, salmon. The exchange functions as a middleman between a provider of salmon and a buyer of salmon and does not handle delivery. They mainly provide guidance and a marketplace for players to trade. As such, access to market information is key. The geographical location is less relevant in the days of almost universal access to the internet, because information is readily available whenever you need it and wherever your location is. Fish Pool is situated in Bergen, which is geographically central in relation to the fish farmers in Norway. This builds trust with the farmers and makes information about developments more easily obtained through news media because of the absence of language- and geographical barriers. Their internet domain is in the EU which is the location of most of their customers abroad. This seems like a good starting point for a successful contract.

Firstly, the geographical location attracts farmers from the country who seek to limit their risk exposure, as well as security in knowing that their products are actually sold. Secondly, and perhaps most important, is that the exchange is a digital marketplace with a global availability. This attracts hedgers whose primary concern is their risk exposure in the spot market, and security in the delivery department. As we saw in chapter 4.1, the market is rather volatile which should be attracting speculators as well.

Fish Pool as a company is dependent on the physical market. The bad numbers for 2012 was caused by a historical drop in salmon spot price in the autumn of 2011. This led to reluctant buyers of salmon contracts, and sellers subsequently sought exposure in the spot market rather than contracts. Naturally this led to a shortage in contract turnover, which directly impacted the bottom line at Fish Pool. This does not necessarily mean that the confidence in Fish Pool has decreased, as both the spot market as well as contracts markets fell this year (Fish Pool, 2013).

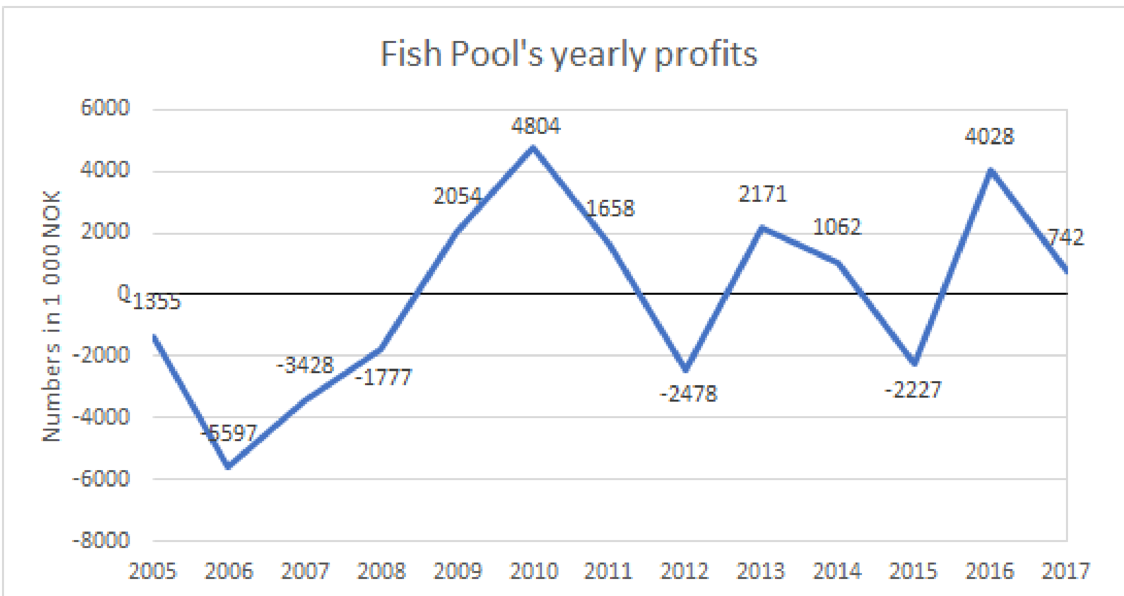

Figure 23 Fish Pool's yearly profits. [23]

Fish Pool is financially dependent on the activity in the physical market. As a result of this, a sharp fall in in oil price led to a tough financial year in 2015. The large drop in the oil price led to a weakening of the NOK. Since the vast majority of the produced salmon is exported, the industry as a whole suffered losses over this. Fish Pool was no exception and had to increase short-term debt in this period (Fish Pool, 2016).

[23] Note to figure 23: From the annual reports we can clearly see that Fish Pool had a "bad year" in 2012 and 2015. Source: (Proff.no, 2019)

4.4.2 The users

As an exchange of goods in the physical market, Fish Pool is dependent on trade members to succeed. The number of trading members at Fish Pool increased steadily from 2006 to 2013 (figure 24). It has in past couple of years fallen slightly.

Figure 24 Number of trading members. [24]

Information regarding number of trading members in the period of 2015 to 2018 were provided by Fish Pool through email, and by Fish Pools annual reports[25]. Fish Pool experienced a good growth in trading members the from 2006 to 2013. However, the number of traders in the period 2015 to 2018 are rather low compared to previous years. As previously mentioned, in 2014 Nasdaq took over as clearinghouse after NOS Clearing were integrated in Nasdaq. The stricter requirements for trading members at Nasdaq are the primary reason for the big drop in trading members from 2013 to 2015. The trade members started declining in 2014 and the trend did not stop in 2015. This year Fish Pool increased the trading fee from 0,08 NOK/kg to 0,1 NOK/kg however, they claim that it did not affect trading, as they put in place incentives (Fish Pool, 2015). It is important to note that the trading volume was not as affected as one might assume by

[24] Note to 24: The years 2008, 2010, 2014 and 2014 are omitted due to unavailable data.

[25] http://fishpool.eu/about/annual-reports/

the reduced number of trading members, seeing that the number of trading members in 2015 were reduced to less than 20% of the number of traders from 2013; and the traded volume was noticeably higher in 2016. This could either mean that the fewer members must have expanded their trading activities, or that newer, larger trade members entered the market (figure 2).

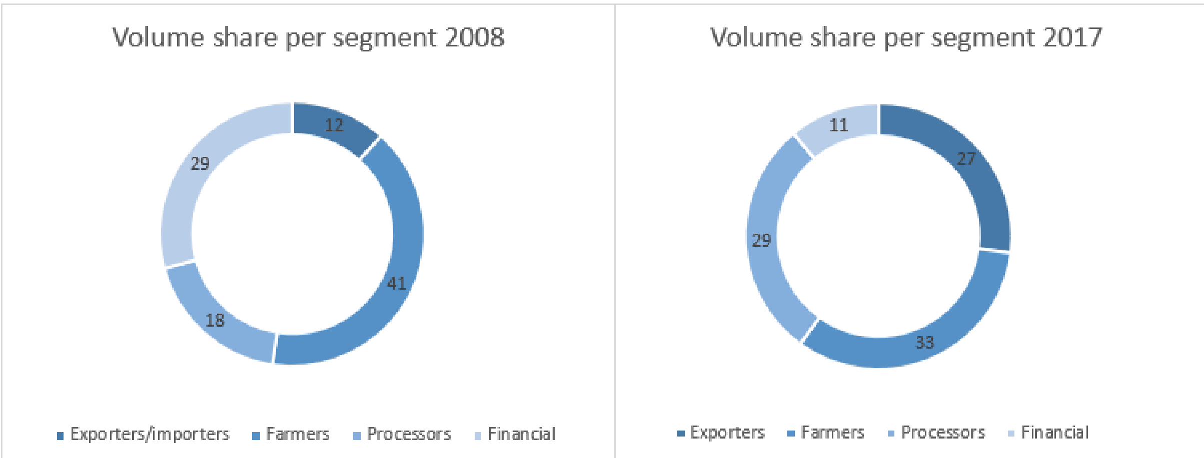

Figure 25 Development of trading members per segment 2007-2017.

Information regarding the volume share of 2017 were provided by Fish Pool through email, while the volume share of the traders for 2008 are accessible from their annual reports (Fish Pool, 2009). The traders at Fish Pool can be divided into different segments (figure 25). Of which, in terms of traded volume, the farmers are the clearly largest segment. In 2008, 41% of the traders were salmon farmers. The situation was similar in 2017 for the farmers with 33%, but the segment of export had grown a lot since 2008. Figure 18 shows how exported salmon has grown which could explain the growth in the exporters segment. While the new demands from Nasdaq in 2014 could explain the reduction in farmers and financial volume shares, it does not directly reveal why the shares for processors has increased. It could be signs of vertical integration or a manifestation of farmers seeking exposure to the spot market.

The gist of it is that the exporters, processors and farmers seem to be the primary segments trading at Fish Pool. These segments are all linked to the supply chain, which are actors primarily interested in limiting their risk exposure. The remaining 11% of the volume could be consisting of speculative trading in 2017.

This, along with the reduction in the financial and farmer segments could be indicators of vertical integration. The segments are dominated by actors with physical biomass. This makes the contract highly dependent on the operating conditions at the physical actors.

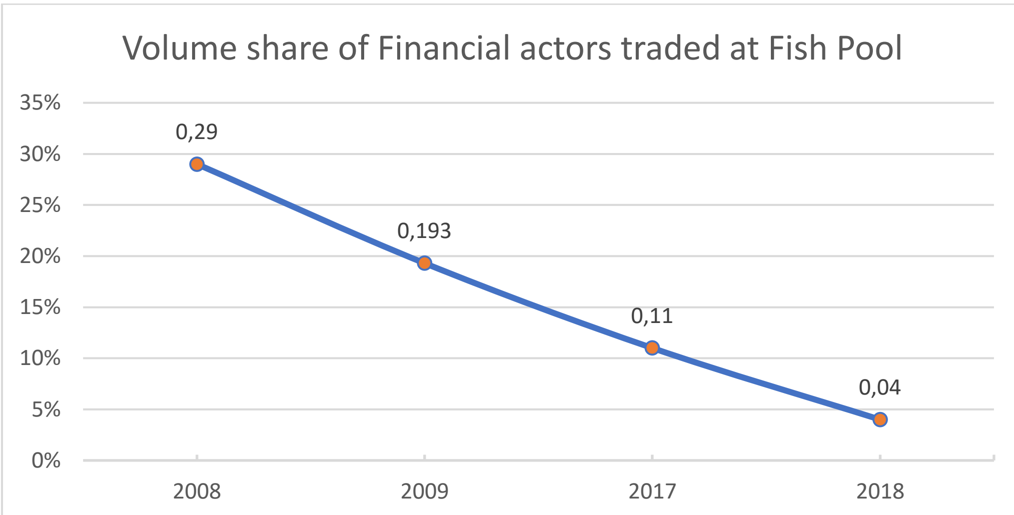

Figure 26 Financial actors in Fish Pool.[26]

Information about the segment for financial actors is unavailable for the period between 2009 and 2017 (figure 26). It has dropped off quite severely from 2017 to 2018 and it does not seem like it has anything to do with the Nasdaq incident. As previously discussed, the volume in equation 1 is greatly affected by the velocity. The velocity seems to be the primary component of concern for the volume as the other factors are indicated to be within acceptable margins. Velocity is a function of speculative activity with the stock, and if this seize, the contract essentially dies. It seems like this could be a major cause for concern.

[26] Note that there is a gap in the data between 2009 and 2017.

5. Conclusion

In a market where the commodity price is highly volatile, it can be difficult to plan expenditures and investments when the income is unpredictable. Futures contracts are known as a good tool for limiting such risk exposure. This thesis has studied the performance of futures contracts that are traded at Fish Pool in the light of four groups of success criteria.

Producers of salmon enjoy a very good operating margin which gives them a good buffer to absorb the price uncertainty in the spot market. They are also more risk tolerant compared to actors in other industries. It makes them crave for the small increases in the spot market rather than the security against the spot prices falling. Few producers seek exposure in the futures market because of the negative expected value. The futures contract is perceived as unnecessary and as the share of traded volume at Fish Pool is dominated by the segments that operate in the physical market, it constitutes a low demand for futures contracts in the hedger department. The market is largely dominated by fewer, larger companies that are increasingly becoming more vertically integrated. This further reduces the demand for price securing instruments, because they remove many points of pricing, and have a more diversified production. The large companies are simply too confident in the current market situation to consider additional price securing instruments. The smaller companies are more vulnerable to fluctuations in the salmon price and as such are more likely to use hedging contracts. This fits well with the observations of other commodities. We saw that the successful contract on soybeans had a rather low operating margin, and the failure of shrimp contracts with an even higher operating margin than salmon.

The low demand for price securing instruments makes the contract illiquid which is detrimental for attracting enough speculative traders to the trading pit. Bergfjord (2007) claims that speculative trade is essential for a futures contract to succeed, and this is also illustrated by equation 1. The volume share of financial actors has decreased severely over the years, and it is likely that the strict requirements put in place by Nasdaq is contributing towards choking this activity. Another factor that may contribute to this trend is the degree of vertical integration. The speculators could become afraid of the companies manipulating the prices based on insider knowledge and exit their positions in the market. Vertical integration also has the effect of pulling down the spot price, which is undesirable for speculators, because they want to buy the contracts low and sell them high.

Our analysis points out that the share of traded volume by the financial actors is decreasing as a result of the low liquidity of the contract. Thus, it seems like the low liquidity caused by risk-tolerant producers with high operating margins is the problem for the Fish Pool futures contract. As seen with the shrimp contract, the relatively safe operating margins with the production of biomass creates a reluctancy towards using price securing instruments. This pattern did not manifest in the soybean contract as the farmers had a much tighter operating margin to contend with.

The contract seems to fail to attract enough hedgers and create a good liquidity, despite providing more price security than the spot market. This removes one of the primary motivators for speculative traders, who mainly seek volatile markets with high liquidity. Fish Pool may also be on its way to mature on a lower level of liquidity. Fish Pool has survived more than a decade, managing to maintain their operations through two financial crises. A lower salmon price would probably be necessary to produce a situation where Fish Pool could reaffirm their position as a viable futures exchange to secure against the volatility of the spot market. In the light of our findings, Fish Pool cannot be considered a success in the present market situation.

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Appendix A

In this appendix we have all the input codes for RStudio version 3.6.0 that have been used to estimate models and create illustrations in the thesis.

RStudio packages used:

```
library(frequencyConnectedness)
library(vars)
library(urca)
library(fGarch)
library(WeightedPortTest)
library(tseries)
library(dplyr)
setwd("~/Skole/Master/Data")
```

Input for estimating the AR-GARCH model:

```
library(readxl)
Manedlig_data <- read_excel("Manedlig_data.xlsx",
                            sheet = "Ark2")
Manedlig_data2<-na.omit(Manedlig_data)
summary(Manedlig_data)
Weighted.LM.test(garch_SpotPrice@residuals, garch_SpotPrice@h.t,lag=8)
plot(garch_SpotPrice@sigma.t,type="l",xlab="Months sinse start",ylab="Spot
volatility",col="blue",ylim=c(0.07,0.12))

sink("Volx_1.txt", append=FALSE, split=TRUE)
cat(garch_SpotPrice@sigma.t,sep="\n")
sink(split=TRUE)
```

Dickey-Fuller tests:

```
summary(ur.df(Manedlig_data$SpotPrice,type="none",lags=8, selectlags="AIC"))
summary(ur.df(Manedlig_data$SpotPrice,type="drift",lags=8,
selectlags="AIC"))
summary(ur.df(Manedlig_data$SpotPrice,type="trend",lags=8,
selectlags="AIC"))

summary(ur.df(Manedlig_data$LogReturns,type="none",lags=8,
selectlags="AIC"))
summary(ur.df(Manedlig_data$LogReturns,type="drift",lags=8,
selectlags="AIC"))
summary(ur.df(Manedlig_data$LogReturns,type="trend",lags=8,
selectlags="AIC"))

summary(ur.df(Manedlig_data$Volatility,type="none",lags=8,
selectlags="AIC"))
summary(ur.df(Manedlig_data$Volatility,type="drift",lags=8,
selectlags="AIC"))
summary(ur.df(Manedlig_data$Volatility,type="trend",lags=8,
selectlags="AIC"))
```

STL decomposition by Loess input:

```
salmon.ts<-ts(Manedlig_data$SpotPrice,start=c(2007,09,31),frequency=12)
salmon.stl<-stl(salmon.ts,s.window="periodic")
plot(salmon.stl)

volatility.ts<-ts(Manedlig_data$Volatility,start=c(2007,09,31),frequency=12)
volatility.stl<-stl(volatility.ts,s.window="periodic")
plot(volatility.stl)
```

RStudio input for estimating the Shrimp volatility:

```
library(readxl)
Volatility_commodities <- read_excel("Volatility commodities.xlsx")
summary(Volatility_commodities)

Shrimpe_r<-Volatility_commodities$LogRetShrimp
garch_Shrimp=garchFit(~arma(0,0)+garch(1,1),data=Shrimpe_r,trace=F,include.m
ean=T,cond.dist="QMLE")
summary(garch_Shrimp)
Weighted.LM.test(garch_Shrimp@residuals, garch_Shrimp@h.t,lag=4)
sink("Volatility_shrimp", append=FALSE, split=TRUE)
cat(garch_Shrimp@sigma.t,sep="\n")
sink(split=TRUE)

shrimp.ts<-
ts(Volatility_commodities$Shrimp,start=c(2007,09,31),frequency=12)
shrimp.stl<-stl(shrimp.ts,s.window="periodic")
plot(shrimp.stl)

volatShrimp.ts<-
ts(Volatility_commodities$VolShrimp,start=c(2007,09,31),frequency=12)
volatShrimp.stl<-stl(volatShrimp.ts,s.window="periodic")
plot(volatShrimp.stl)
```

Johansen test on the six different commodities:

```
Comodity_spot_prices <- read_excel("Commodity spot prices.xlsx",
                                   sheet = "Ark3")
Salm<-ts(Comodity_spot_prices$Salmon)
Shrimp<-ts(Comodity_spot_prices$Shrimp)
Poultry<-ts(Comodity_spot_prices$Poultry)
Lamb<-ts(Comodity_spot_prices$Lamb)
Corn<-ts(Comodity_spot_prices$Corn)
Soy<-ts(Comodity_spot_prices$Soybeans)

jotest=ca.jo(data.frame(Salm,Shrimp,Poultry,Lamb,Corn,Soy), type="trace",
K=2, ecdet="none", spec="longrun")
summary(jotest)
```

Johansen test on the three weight classes included in the FPI:

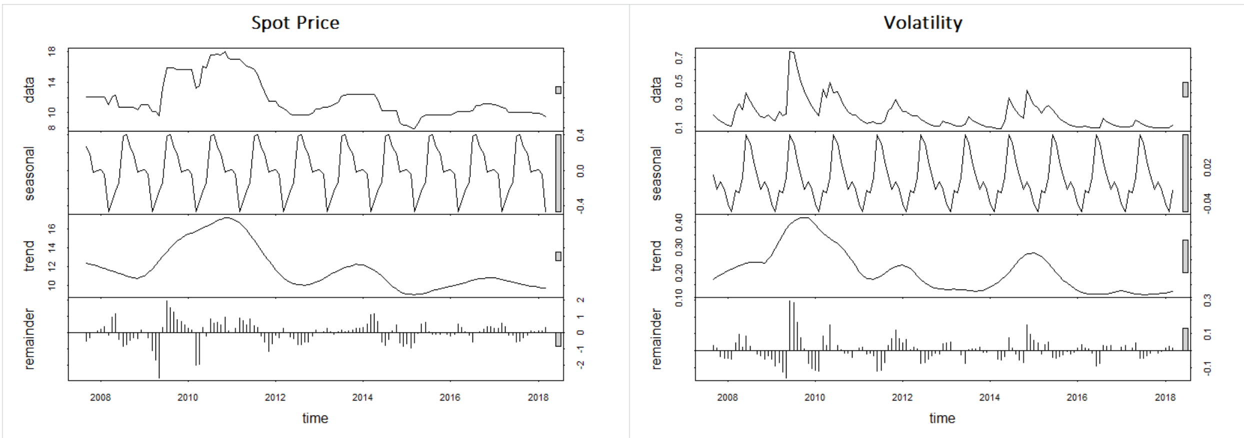
```
Comodity_spot_prices2 <- read_excel("Commodity spot prices.xlsx",
                                    sheet = "Ark4")
small<-ts(Comodity_spot_prices2$small)
medium<-ts(Comodity_spot_prices2$medium)
large<-ts(Comodity_spot_prices2$large)

jotest=ca.jo(data.frame(small,medium,large), type="trace", K=2,
ecdet="none", spec="longrun")
summary(jotest)
```

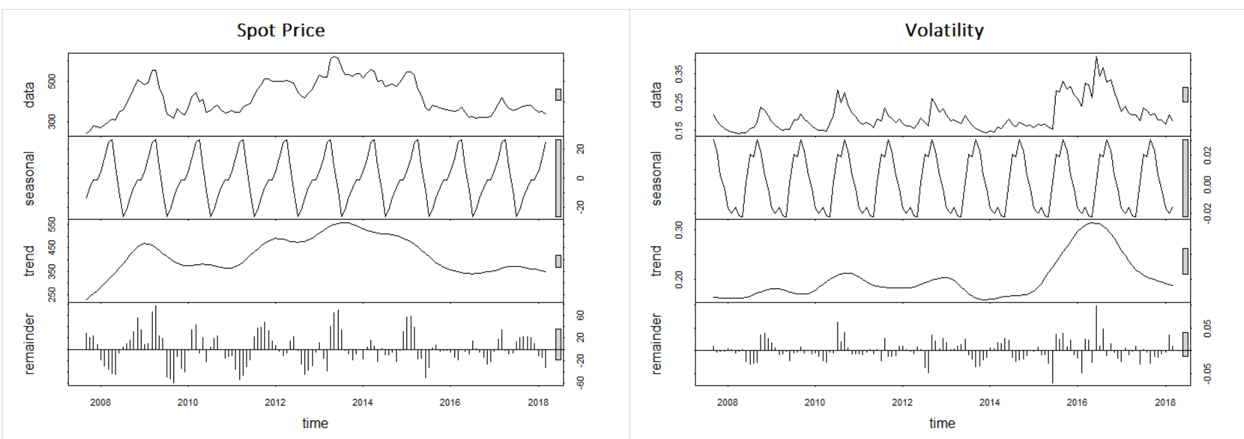
Appendix B

This appendix includes a summary of the data used for analysis in the thesis.

STL decomposition of shrimp:



STL decomposition of soybeans:



Summary of the data for spot price of the other commodities:

- Lamb: frozen carcass Smithfield London, US cents per pound.
- Shrimp: Thailand Whiteleg Shrimp 70 Shrimps/Kg Spot Price. US$ per pound
- Poultry: Whole bird spot price, Ready-to-cook, whole, iced, US cents per pound.
- Corn/maize: U.S. No.2 Yellow; FOB Gulf of Mexico; U.S. price; US$ per metric ton.
- Soybeans: No. 2 yellow and par, US$ per metric ton.