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Predicting Salmon Futures Returns

An empirical study from 2007 to 2019

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Abstract

In order to investigate the factors that influence the return of salmon futures, we construct a fully hedged, passive, front month rolling portfolio of long positions in these contracts. We show that the excess return on such a portfolio is affected by momentum, spot volatility, term structure and seasonality, but not by systematic risk or basis. When including transaction costs, the return on this portfolio is less than that of the market, but with a much higher volatility. However, when predicting subsequent monthly excess returns using a simple regression model based on the factors we have identified, we are able to construct a portfolio that significantly outperforms the market with no systematic risk.

Keywords: Commodity futures, salmon, multi-factor model, asset pricing

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We have found the process of writing this thesis to be both challenging and rewarding. Most of all, we have learned a lot and are grateful for the opportunity to be able to study a topic which is of great interest to us both. We hope this interest extends to the reader, and that he or she will find our writing and data presentations engaging. Any mistakes or miscalculations in this paper are ours alone.

Bergen, 2019

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1. Introduction

Financial investment in commodity futures has gained increased academic interest since the stark rise of commodity futures index investment following the mid 2000's. Many studies at that time indicated that the return and volatility of commodity futures were comparable to that of equities, but with little correlation to the overall market. Suddenly, commodity futures appealed to many investors who just came out of the dot-com bubble, resulting in a large influx of investment that drove prices up. Investors focused mainly on indexed commodity futures, resulting in an increased correlation between these contracts and seemingly unrelated assets. In the spring of 2011, the continued run of positive returns on long positions in most of these contracts ended. Since then, the S&P GSCI, a widely recognized commodity futures index, has fallen over 40%[1].

In 2006, trading at Fish Pool Salmon Exchange opened in Bergen, with proximity to many salmon producers in Norway, the largest farmed salmon producing nation by far. Since 2007, the exchange has offered futures contracts, giving market participants the chance to hedge the volatile spot price of salmon. Some research has been done regarding the efficiency and the premiums for the contracts. However, limited research has been done with regards to the returns of salmon futures from the perspective of an investor. We aim to shed some light on this topic by creating an investable portfolio of these contracts and investigating which factors impact its returns, and to what extent these factors can be used to predict future returns. To our knowledge, we are the first to use this method on salmon futures and we believe our findings should be of interest to anyone wanting to understand the pricing mechanisms of salmon futures or seeking to compare the returns of salmon futures to that of other assets such as equities, bonds, real estate or other commodity futures.

[1] Measured in USD

2. Literature review

Gorton and Rouwenhorst (2006) analyze the properties of commodity futures as an investment asset. They find that in the period 1959-2004, the return and volatility of passive, long positions in commodity futures have been equivalent to that of stocks. Furthermore, the returns of commodity futures had negative correlation to the returns of both stocks and bonds, presenting an opportunity for diversification for investors. Erb and Harvey (2006) show that diversification by investing in commodities would have historically improved the performance of equity dominated portfolios. Gorton and Rouwenhorst (2006) also find that commodity futures returns are positively correlated to inflation, in contrast with stocks and bonds. Roughly a decade later they investigate the changes in futures returns since their original paper together with Bhardwaj (2015). They did not find that the returns had become statistically lower. Erb and Harvey (2006) find that the Goldman Sachs Commodity Index (GSCI) outperformed the S&P 500 total over the period December 1969 to May 2004. However, the returns of commodity futures have been disappointing in recent years, as reflected by the negative returns of S&P GSCI over the last decade. Irwin et al. (2019) reflect that this is partly due to costs incurred by investors when trading, which is often not included in academic papers.

Tang and Xiong (2010) show that indexed commodity futures had become increasingly correlated with each other and with other asset classes due to the large influx of index investment since the mid 2000's; a process referred to as the financialization of commodities, which resulted in a volatility spillover effect. Chan et al. (2018) find that the impact of financialization on volatility varies across commodity type. Tang and Xiong (2010) concluded that the contracts were no longer priced solely based on fundamentals, but also by the behavior of diversified financial investors. As a result, the diversification effects of investing in indexed commodity futures may be lower than previously assumed. However, their findings show little to no support of any such effects in non-indexed commodities, indicating that investment in these commodity futures still presents good diversification opportunities for investors.

In their original paper, Gorton and Rouwenhorst (2006) present their theory regarding the returns of commodity futures. According to them, the source of returns for investors is due to the risk premium, the difference between the current futures price and the expected future spot price. As deviations from the expected future spot price is by definition unexpected, they should average out to zero. Hence, a purchaser of futures will on average earn money if the futures price is set below the expected future spot price, meaning that the futures prices are downward biased estimates of future spot price. On the other hand, if the futures price is set above the expected future spot price (upward biased estimates), a seller of futures will on average earn money. As such, expected movements in spot prices are not a source of return for investors in futures, rather it is the risk premium plus any unexpected spot price movements.

According to Keynes (1930) and Hicks (1939), risk premiums should on average accrue to the buyers of futures. Their theory postulates that this is due to net demand by producers of commodities for spot price hedging in the futures market, and that speculators will provide this insurance at a premium. This has been the basis for the theory of normal backwardation. As such, commodity markets with rising futures prices are often referred to as being in "normal backwardation", whereas the opposite scenario is referred to as "contango".

Building on the theory of normal backwardation, the hedging pressure hypothesis of Cootner (1960) and Hirshleifer (1988) is perhaps one of the most important theories regarding commodity futures pricing. In short, the theory predicate that premiums are positive when hedgers are net short, and negative when they are net long. Short hedgers are usually commodity producers and long hedgers are usually commodity consumers[2]. Using nearest to maturity contract returns in 22 futures from 1967 to 1989, Bessembinder (1992) conclude that mean returns depend on net hedging for agricultural and currency contracts. De Roon et al. (2000) find that hedging pressure in futures markets as well as and hedging pressures on other markets (cross-hedging pressures) significantly impact futures return.

Another important theory in the realm of commodity futures pricing is known as the theory of storage and was developed by Kaldor (1939), Working (1949), Brennan (1958), and Telser (1958). In this framework, the return from purchasing a commodity and selling it for future delivery should, assuming no arbitrage, equal the interest forgone plus the marginal storage cost[3] minus the marginal convenience yield[4]. Hence, a purchaser of futures should presume to earn a return equal to that of the convenience yield minus the interest and the storage costs. As such, backwardated markets must have a convenience yield that exceed the cost of storage and forgone interest. Furthermore, according to the theory of storage, there is a negative relationship between inventories and convenience yields. A common feature among strongly backwardated commodities is that they are difficult to store, as shown by Eagleeye and Till (2003).

Gorton et al. (2013) combine the theory of normal backwardation and the theory of storage by including futures markets and risk-averse investors in the same model. They assume that holders of commodities face a bankruptcy cost, and therefore have a hedging motive. Futures markets provides the holders with an opportunity to hedge bankruptcy costs, and therefore use the futures market to transfer future spot price risk to risk averse investors, at a premium. The model determines the risk premium paid by the holders to the investors, as a function of

[2] Consumers refer to industries using commodities as input factors for production. Examples could be refineries buying oil or bread producers buying grains.

[3] Storage costs can often include financing costs and income earned on renting out the asset.

[4] Convenience yield is the benefit rate of holding the physical asset compared to holding the futures contract.

the expected bankruptcy costs, the degree of risk aversion of the investors, and the level of inventories.

Many studies have also looked at the relationship between futures returns and systematic risk. Dusak (1973) analyze risk premiums in three agricultural commodity futures with regards to the Capital Asset Pricing Model (CAPM). All her coefficient estimates are close to zero. Bodie and Rosansky (1980) conclude that the CAPM does not hold when looking at different commodity futures. Questioning the validity of Dusak's selection of the S&P 500 as the market proxy, Carter et al. (1983) include the Dow Jones Commodity index to augment the market portfolio. They find systematic risk significantly different from zero. Chang et al. (1990) also identify significant systematic risk for copper, platinum and silver. Hirshleifer (1988, 1990) shows that both systematic risk and commodity specific factors impact futures prices.

Using a three-factor model that includes systematic risk, inventory levels and hedging pressure, that allows for time variation with relation to macroeconomic variables, Khan et al. (2008) find mixed results for crude oil, natural gas, copper and gold. Their evidence suggests significant betas for all factors with regards to oil and gas. However, the systematic factor is not significant for the metal futures. Chan et al (2017) concludes that "significant betas and risk premiums are associated with momentum effects, term structure, and speculators' hedging pressure." Furthermore, their results show "that market premium is not an important component in explaining commodity futures returns". Lastly, they also provide evidence for a liquidity premium in commodity futures markets.

Recent studies on the pricing of commodity futures find that both momentum and basis are important factors (Bakshi et al. 2014, De Roon et al. 2014, and Yang 2013). Even more recently, Sakkas and Tessaromatis (2018) show that their multi-factor commodity futures portfolio combining momentum and basis factors, significantly outperforms widely used commodity benchmarks. Hong and Yogo (2012) note that basis significantly predicts futures returns in all their model specifications.

Erb and Harvey (2006) find evidence that term structure[5] is related to subsequent returns. Basu and Miffre (2013) also find that term structure is a significant factor, even after controlling for hedging pressure and momentum. The staggering returns associated with term structure strategies suggest that term structure is an important factor for futures returns.

Fuertes et al. (2016) investigate the relationship between idiosyncratic volatility and mean returns in commodity futures markets. They find that idiosyncratic risk is negatively linked to returns, and that portfolios buying low volatility commodities and shorting high volatility commodities offer large abnormal returns. However, the researchers find that idiosyncratic volatility is not a priced factor when accounting for the premiums related to the contango and backwardation fundamentals.

Asche et al. (2016a) study the determinants of risk premiums in Atlantic salmon futures of different maturities. They find that there is indeed a risk premium in the contracts, which on average is paid by the sellers of salmon futures, congruent with Keynes theory. Furthermore, they conclude that basis and seasonality are the main determinants of the variation in the premiums. In addition, they find signs of low liquidity in the market. Asche et al. (2015) further indicate that the convenience yield of salmon depends on expected growth which is highly seasonal as it depends on sea temperature. Also looking at contracts with different maturities, Ewald and Ouyang (2017) find that seasonality is an important determinant in the salmon spot and futures markets using a seasonal stochastic convenience yield. Asche et al. (2016b) study the spot-forward relationship in the Atlantic salmon market. They conclude that the salmon futures are an inefficient price discovery tool due to the immaturity of the market.

[5] Term structure refers to the shape of the futures curve.

Chen and Scholtens (2019) also find that the salmon futures do not perform a price discovery role and speculate it is due to low liquidity. Bloznelis (2018) show that the hedging efficiency for salmon futures is significant, even though longer contracts again showed signs of illiquidity. Asche and Misund (2016) also find that salmon futures are an efficient hedging tool for reducing risk. Ewald and Salehi (2015) analyze the salmon futures in context of the CAPM and a three-factor model using the share prices of two major salmon producers as the additional factors to systematic risk. They show that betas are mainly zero, and mostly insignificant for most maturities.

3. Commodities and commodity futures

A commodity is an economic good or service that is interchangeable, meaning that the market treats these goods as equivalent, with no regards to who the producers are. Hence, goods and services that are to be treated as commodities must be easy to standardize and quality check. Furthermore, there must be enough volume produced and traded to ensure liquidity. As such, typical commodities are input factors in production of other goods, such as agricultural harvest like wheat and grains, and metals like gold and aluminum. The largest sector of commodities today is the energy sector, including commodities like crude oil, natural gas and coal. Commodities are often traded over exchanges, such as the Chicago Mercantile Exchange (CME) or the London Metal Exchange (LME). These exchanges stipulate the rules of trading and the quality and standard of the underlying goods.

3.1 Commodity futures

Traditionally, a commodity futures is a contract between a buyer and a seller, where a specified amount of the commodity and its price (the futures price) is agreed upon for delivery and payment at a future date (expiration or maturity date). As payment is to be done at delivery, there is normally no financial transaction made when the contract is entered.

A futures contract differs from options by being an obligation by both parties. Therefore, the value of the contract is the difference between the expected spot price at maturity and the futures price. For a specified future date, as time goes by, the futures price will converge towards the spot price. This is because, at expiration, the futures price and the spot price ought to be the same, since they both reflect delivery of the same good at the same time.

Normally, a futures contract is offset daily by a clearing house, ensuring that both parties have no default risk at expiration. The daily settlements are transacted between the contract parties' accounts at the clearing house. The daily settlements equal the change in futures price. Hence, at maturity the sum of all settlements amount to the difference between the spot price and the original futures price. A contract which is not offset daily, and in which the entire payment is to be made at expiration, is often referred to as a forward contract.

3.2 Normal and inverted market

The terms normal and inverted markets refer to how futures prices compare to each other at different maturities (Mitchell, 2019). In a normal market the spot price and the nearer contracts are priced lower than contracts with longer maturity, resulting in an upward sloping futures curve. In an inverted market the opposite is true, resulting in a downward sloping futures curve. A futures contract may be inverted for some maturities and normal for others, resulting in a futures curve which is downward sloping for some periods and upward sloping for others. The determinants for the slope of the futures curve include supply and demand shocks in the short term, expectations for future spot prices and the costs and benefits of holding the underlying asset versus the futures contract.

3.3 Contango and normal backwardation

A futures market in contango refers to a market where the futures contract decreases in price as it approaches maturity (Harper, 2019). This is often confused with a normal market, as one could easily assume that since futures prices in a normal market are higher than the spot, the prices must come down as the contract approaches maturity. However, this does not account for the fact that the spot price could move during the holding period. Normal backwardation, or sometimes just called backwardation, refers to when a futures contract increases in price as it approaches maturity. Again, normal backwardation is often confused with an inverted market. It is true however, that a normal market often results in contango, and an inverted market often results in normal backwardation, but it is not always the case. The return of an investor holding a futures contract is based on whether the contract is in contango or normal backwardation, not by the shape of the futures curve. An investor who is long in a futures contract would earn a positive return if the market is in backwardation (rising futures prices), and an investor who is short would do the same if the market is in contango (falling futures prices). A futures contract may be in backwardation for some periods and in contango for others[6].

4. The salmon market

Salmon farming began in the 1960's and has since surpassed wild salmon fishing in terms of production volume. Since then, salmon has become a frequently traded commodity, as the production has rapidly grown because of an increase in global fish consumption. Normal market size for farmed salmon is 4-5 kg, but farmers also offer both larger and smaller sizes[7]. Farmed salmon is considered a fresh product with a short shelf life of about three weeks. The total production cycle can vary between 24 - 40 months.

Norway is the biggest supplier of farmed salmon, producing more than 50 percent of the world's production. Currently, farmed salmon is Norway's second largest export after oil and gas and yields more than 67 billion NOK annually, which is approximately 2-3 percent of Norway's

[6] See Appendix 5 for a figure showing contango and backwardation.
[7] See Appendix 4 for size distribution.

GDP (Norwegian Seafood Council, 2019). In terms of production, Mowi, formerly known as Marine Harvest, is the biggest salmon farmer in both Norway and overseas, having facilities in Chile, Scotland and Canada[8].

4.1 Supply and demand of salmon

The price for farmed salmon depends on several factors including the size of the salmon, the production processing and demand factors. Only a few places are suitable for farming salmon as water temperature and sea current are important factors. The industry is also heavily regulated. Fresh salmon is a highly perishable commodity and must be consumed shortly after harvest. Furthermore, growing salmon normally takes over two years. These factors combined make the supply quite inelastic whereas the demand fluctuates throughout the year. This creates highly volatile prices (Mowi, 2019).

4.2 Fish Pool ASA

Fish Pool is an international marketplace for buying and selling financial contracts related to salmon. Fish Pool has over 200 trade members and as of 2019 offers only futures contracts, though they have previously offered financial options. The marketplace was established in 2005 in Bergen, Norway, and 97 percent of its shares is owned by Oslo Stock Exchange. Their mission is to create predictability in risk exposed fish and seafood markets (Fish Pool, 2019).

4.3 Fish Pool Index

Salmon prices can be hard to quantify as they include different segments and are often traded on private agreements, rather than on a centralized commodity exchange. Therefore, Fish Pool have created Fish Pool Index (FPI), a synthetic market price for salmon that aims to reflect the true spot price. FPI is constructed as a weekly weighted average of Nasdaq salmon index

[8] See Appendix 4 for figures on salmon production.

(85%), Fish Pool European buyers Index (10%) and Norwegian export statistics (SSB) (5%). Furthermore, FPI is based on a weekly weighted average of the most traded types of salmon in terms of weight (3-6 kg) and quality.

4.4 Fish Pool Futures

Futures contracts on Fish Pool are financial contracts and are not settled by delivery of salmon. Rather, they are settled against the Fish Pool Index (FPI). Contracts are standardized for monthly delivery, and as such are settled against the monthly FPI. A futures contract will not normally expire until the second Friday in the month following it, which is when the FPI monthly average for that month is published. Hence, a February contract will normally expire somewhere between the 7th and 15th of March.

Fish Pool futures are cleared by Nasdaq Clearing, which means that settlements are made daily against the current futures price in the market. To enter a futures contract at Fish Pool, one must have an account at Nasdaq Clearing in which one must deposit a minimum capital requirement calculated as a percentage of the contract price. This percentage will change according to the risks associated with the contract. As the daily futures price change, money will be transferred between the contract parties' accounts. If one of the parties' deposits become lower than the margin requirement, they will be notified and required to refill it. Being a member at Fish Pool and using Nasdaq Clearing incurs both fixed and variable costs[9].

4.5 Spot price development

Salmon spot prices, as reflected by the Fish Pool Index (FPI), has been quite volatile in the sample period. This has given risk averse market participants good reason for hedging their price risk using futures contracts. It is also worth noting that monthly salmon prices have

[9] See Appendix 1 for information on costs at Fish Pool.

tended to increase during winter and spring and decreased during summer and fall. According to Ewald and Ouyang (2017), this seasonal behavior is due to several factors, including the availability and production of different weights of salmon, the water temperature (which in in turn affects the growth capability) and demand fluctuations. However, overall, price has steadily increased, offering salmon producers better margins and opportunities.

5. Constructing an investable salmon futures portfolio

To analyze the returns of salmon futures, we follow the methodology presented by Gorton and Rouwenhorst (2006). The portfolio represents a passive, long position in the contracts. We select the nearest to maturity contract which does not expire in the following month, at the end of each month[10]. This contract is henceforth referred to as the front month contract. At the same time, the position is fully hedged with 3-month treasury bills issued by the Norwegian Central Bank. This is done because futures only require a small amount of the total value of the contract to be invested up front. Hence, there is inherent leverage when entering a futures position. Assuming a fully collateralized position removes this leverage and makes the returns comparable to that of non-leveraged assets. The total return from such a portfolio would be the excess returns[11] from rolling the futures, plus any interest gained from the collateralized position minus transaction costs. Not very surprisingly, the returns of the portfolio are closely linked to the changes in spot price, as can be seen in figure 1.

[10] See Appendix 1 for a detailed explanation of how the portfolio is constructed.

[11] This paper does not define excess returns in the traditional way. We are not referring to the return in excess of expected return, but rather the return gained by rolling a futures contract.

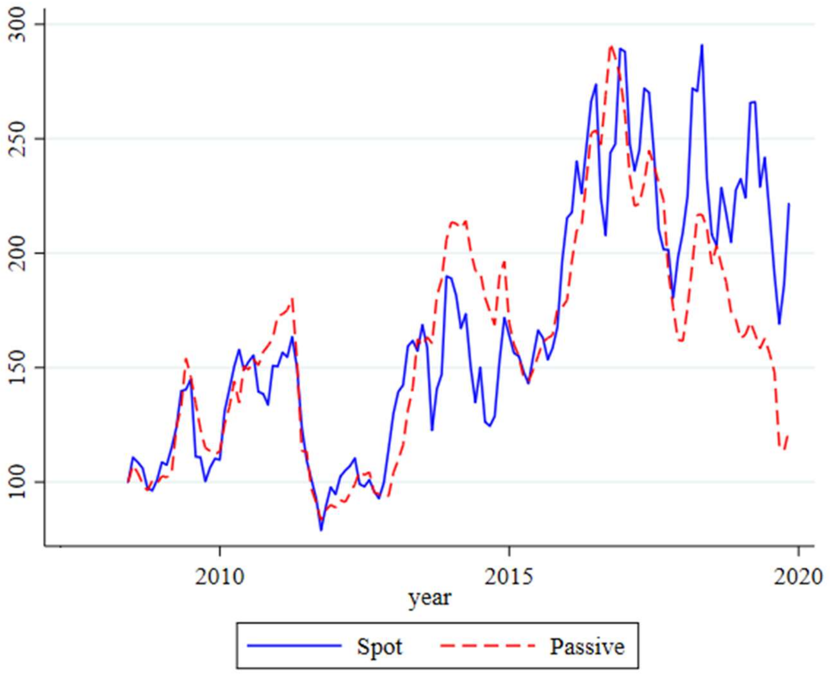


Figure 1: Returns from a passive rolling portfolio of salmon futures compared to the spot price of salmon (FPI).

From January 2007 to November 2019 the portfolio yielded 9.7 %. However, we can see that the portfolio was up almost 200 % by the end of 2016 and has been in almost continual contango since. Looking at the graph, there seems to be prolonged periods up to 2-3 years where the contracts are mostly in backwardation, followed by roughly the same length of periods in contango. This pattern is also closely linked to the spot price development and may indicate that hedgers continually fail to correctly estimate future spot prices. However, forecasting expected spot prices is outside the scope of this paper and we will assume that expected spot prices are the realized prices. We do not believe this is a strong assumption as we are examining short term contracts, 1-2 months in length. Furthermore, deviations from the expected spot price must be unexpected and therefore should average out to zero over time. As such, returns should on average be caused by the risk premiums, and we can extrapolate meaningful interpretations relating to theoretical frameworks regarding risk premiums in commodity markets.

6. Preliminary model specifications

In order to identify the factors that impact the excess returns of our portfolio, we specify a preliminary model. Following Gorton et al. (2013)[12] we define the monthly futures excess returns of this portfolio as:

$$r_t^e = \frac{F_{t,T} - F_{t-1,T}}{F_{t-1,T}} \tag{1}$$

where $F_{t,T}$ is the futures price at the end of month t for the contract whose expiration month T is following t, and $F_{t-1,T}$ is the futures price of that same contract at the end of month t-1.

To identify what factors are important in determining the excess returns, we formulate a model that includes well known commodity futures factors. Net hedging pressure has been proven to predict commodity futures returns in many studies. However, there are currently no available datasets to test this hypothesis for salmon futures. As basis and seasonality have been shown to be important determinants of salmon futures premiums, we find it natural to include them in our model. Seasonality is not likely the cause for premiums itself, however, including it can correct for monthly effects such as seasonal change in hedging pressure or supply and demand factors. To test for seasonality, we include monthly dummies for each month except January:

$$d_{t,i} = \begin{cases} 0, & if\ i \neq month_t \\ 1, & if\ i = month_t \end{cases} \tag{2}$$

Commonly, basis is referred to the difference between the spot price and the futures price. As we have no daily data for spot prices, we find it natural to use the nearest to maturity contract futures price at the end of month t as a substitute, mimicking the procedures by Gorton et al.

[12] Gorton et al. define the succeeding monthly return whereas we define the preceding monthly return.

(2013) and Sakkas and Tessaromatis (2018). At the end of each month, we will roll to the contract which expires at $t + 2$. The basis can thus be defined as:

$$b_t = \frac{F_{t,t+2} - F_{t,t+1}}{F_{t,t+1}} \tag{3}$$

where $F_{t,\,t+2}$ is the futures price at the end of month t for the contract which expires in month $t + 2$, and $F_{t,\,t+1}$ is the futures price at the same date for the contract which expires in month $t + 1$.

Momentum has been shown to predict commodity futures returns in many research papers. To test for momentum, we include a lagged variable of the excess return for salmon futures. Momentum is defined as:

$$m_t = r^e_{t-1} \tag{4}$$

Spot volatility could affect the demand for hedging and is also included. It is defined as the standard deviation of the last 12 months of the monthly spot price:

$$v_t = \sqrt{\tfrac{1}{12}\textstyle\sum_{i=-12}^{0}(r^e_i - E(r^e_{i,t}))^2} \tag{5}$$

Term structure has also been shown to be related to returns. We include variables for the monthly difference in futures prices up to six months ahead. As such, these variables contain information regarding the shape of the futures curve up to half a year onward. These variables are defined as:

$$s_{t,} = \frac{F_{t,T} - F_{t,T-1}}{F_{t,T-1}} \tag{6}$$

where $F_{t,\,T}$ is the futures price at the end of month t for the contract which expires in month T, and $F_{t,\,T-1}$ is the futures price at the same date for the contract which expires in month $T-1$. $T = \{t+3,\ t+4,\ t+5,\ t+6\}$

Lastly, we include systematic risk, reflected by the correlation with the market return. The market return is defined as:

$$mr_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{7}$$

where P_t is the value of the market portfolio at t and P_{t-1} is the value of the market portfolio at $t - 1$.

Using these factors, we can specify a model for the excess returns, making sure to lag the necessary variables in accordance with our variable definitions:

$$r^e_{t+1} = \alpha + \beta mr_{t+1} + \lambda m_{t+1} + \mu b_t + \gamma v_t + \sum_{i=3}^{6} \omega_i s_{t,i} + \sum_{i=1}^{11} \delta_i d_{t+1,i} + \varepsilon_{t+1} \tag{8}$$

where we have term structure variables from 3 months to 6 months ahead and 11 dummy variables for each month except January. The reason why basis, volatility and term structure are lagged is because they need to predict subsequent returns. Returns at $t+1$ is the return from t to $t+1$. Therefore, basis, volatility and term structure at t need to determine following returns at $t+1$. Momentum is also a lagged variable as it is defined as the first lag of excess return.

7. Data

Salmon spot and futures prices, denoted in NOK, are obtained from Fish Pool (2019) and cover the time period June 2006 - November 2019. As futures first started trading in 2007[13], we limit prices to the period starting from that year. Spot prices are monthly averages, whereas futures prices are quoted daily for periods up to four years, depending on the contracts available at that date. Daily treasury bill interest rates are obtained from the Norwegian Central Bank (Norges Bank, 2019a). As a proxy for the market, we use the global multi-asset market portfolio weights as calculated by Doeswijk et al. (2019) combined with the values of widely used asset specific indices; the FTSE Global All Cap Total Return Index for equities, MSCI Global Real Estate Total Return Index for real estate, a combination of 10% of the S&P GSCI Total Return Index and 90% of the LBMA Gold Bullion Price for commodities and the Bloomberg Barclays Global Aggregate Total Return Index for bonds. The latter is obtained from Bloomberg and the rest are obtained from Thomson Reuters Datastream. The value of the market portfolio is transformed from USD to NOK using daily exchange rates from the Norwegian Central Bank (Norges Bank, 2019b).

8. Respecification and results

After running our regression model from equation (8) we perform some diagnostic tests to make sure our specification is not flawed. Durbin-Watson test results do not indicate problems with serial correlation at a statistically significant level. Performing a variance inflation factor (VIF) test does not indicate issues with multicollinearity. The residuals have zero mean and have quite normally distributed plots[14]. However, Ramsey's Reset test indicate that there are non-linear versions of the dependent variables which should be included. Furthermore, Cook-Weisberg test indicate issues with heteroskedasticity.

[13] Earlier prices were based on prices for forward contracts.

[14] See Appendix 2 for diagnostic tests and residual plots.

We respecify our model by including momentum factors raised to the power of two, three and four. Including lagged versions of the momentum factor is also done to eliminate serial correlation, if there is any. Our model is performed with different specifications which can be seen in table 1. Specification 1 has none of the issues of the original specification. Heteroskedasticity is still a slight issue in specification 2 and 4. The non-linear momentum variables have indications of multicollinearity, ranging from VIF factors of 4-11 in all specifications. However, none of these issues should cause biased estimates in the regression models, only increased coefficient standard errors.

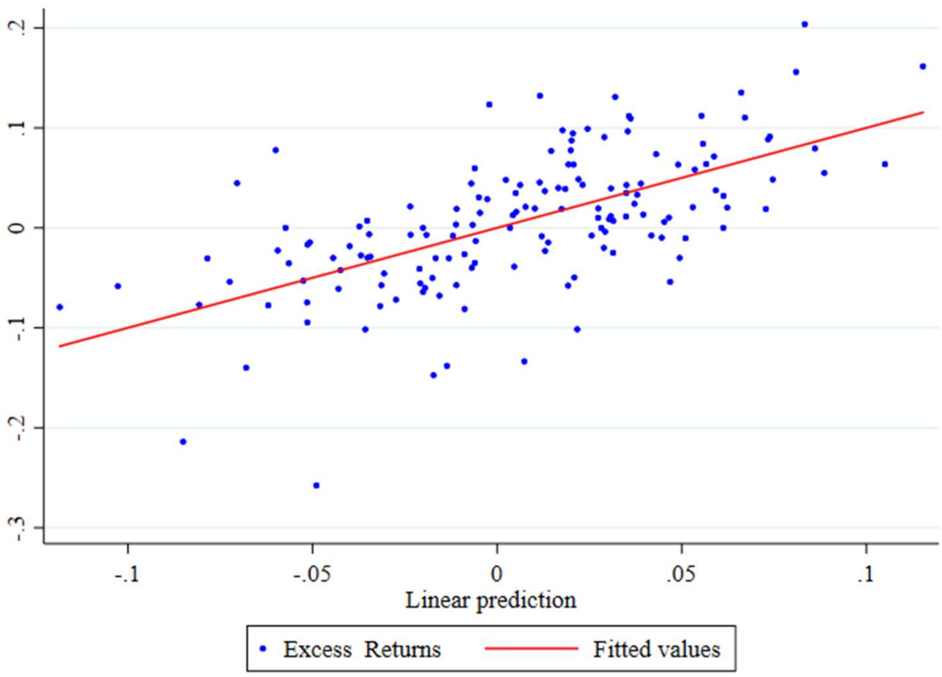


Figure 2: Scatterplot of excess returns and fitted values from specification 1.

Table 1: Regression results

Excess return	(1)	(2)	(3)	(4)
Market return	0.0571		0.0959	
Basis	-0.101	-0.0108	-0.00575	
Spot volatility	-0.514*		-0.467	-0.543**
Momentum	0.458***	0.521***	0.471***	0.447***
Momentum^2	-2.605*	-3.215**	-2.724*	-2.715**
Momentum^3	-1.672	-3.146	-3.802	
Momentum^4	72.74**	72.31**	57.12	75.51***
L1.Momentum	0.177*		0.163*	0.143*
L2.Momentum	-0.0668		-0.121	
Structure 3	0.620***		0.302	0.623***
Structure 4	0.114		-0.145	
Structure 5	-0.178		-0.312	
Structure 6	0.568**		0.287	0.546***
February	-0.00546	-0.00654		-0.00163
March	0.0125	0.00923		0.0114
April	-0.0573**	-0.0449*		-0.0546**
May	-0.00789	0.0157		-0.00820
June	-0.0706**	-0.0431		-0.0698**
July	-0.0685**	-0.0413*		-0.0665***
August	-0.0990***	-0.0579**		-0.0991***
September	-0.0587**	-0.0197		-0.0634**
October	-0.0129	0.0137		-0.0116
November	-0.0412	-0.0223		-0.0389
December	-0.0457*	-0.0258		-0.0459*
Constant	0.0961***	0.0304*	0.0531*	0.0980***
N	150	153	150	152
R^2	0.3927	0.2896	0.2430	0.3772

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These results suggest that momentum, spot volatility, term structure and seasonality are all important factors in determining the excess returns of salmon futures, whereas systematic risk and basis are not. The coefficients and significance of the momentum variables suggest that there is strong serial correlation in the returns. There seems to be non-linear relationships between excess return and momentum in addition to linear relationships. Miffre and Rallis

(2007) relate the momentum factor to the theories of contango and backwardation. However, the reason why contracts which have previously been in contango or backwardation tend to continue in the same state into the future is not clear. Spot volatility is significant in most specifications and indicate somewhat surprisingly that increased spot volatility leads to lower excess returns. Perhaps it is customers who are most sensitive to spot volatility, however this is somewhat counter intuitive. Another explanation could be that periods with higher volatility is often linked to price falls. This could prompt consumers to lock in a fixed lower price, whereas producers are betting on an increase in price and are not seeking to hedge the current price risk. The result would thus be a net long hedging pressure which should result in negative excess returns on long positions. A third explanation is that the factors of contango and backwardation are not properly accounted for in our model, as indicated by Fuertes et al. (2016).

There seems to be a strong relationship between seasonality and the excess returns, as many of the monthly dummies are significant in most specifications. This is congruent with previous findings (Asche et al. 2016a, Ewald and Ouyang 2017). We believe this could be linked to multiple factors. Hedging demand could fluctuate throughout the year with response to supply and demand outlooks. The convenience yield also fluctuates in response to supply and demand factors such as growth rates and storability, which change with the seasons (Asche et al., 2015). Spot price also tend to be cyclical which in turn could affect demand for hedging.

Only two term structure variables are significant in any of the specifications, the variables for curve structure at 3 and 6 months ahead. In all specifications they have positive coefficients, suggesting that upward sloping futures curves tend to be downward biased estimates of future price, and downward sloping futures curves tend to be upward biased estimates of future price. This because, when excess returns have been positive, the futures prices must have been downward biased estimates, causing the futures prices to rise when approaching maturity, and vice versa when they have been negative. Hence, a normal market (upward sloping futures curve) tends to result in backwardation (rising futures prices), and an inverted market (downward sloping futures curve) tend to result in contango (falling futures prices). Again, this is a somewhat puzzling finding because it suggests that when spot prices are going to rise it is the producers who tend to hedge, and when spot prices are going to fall it is the consumers who tend to hedge. This would be the opposite of what one would expect with rational agents. One should however be a little cautious in interpreting these results too strongly as we have no significant coefficients for basis, which would give a full depiction of the relationship between the futures curve and the subsequent excess returns. Asche et al. (2016a) however, find that basis is linked to premiums. As we only include front month contracts in our study, the results do not necessarily contradict the relationship between basis and premiums in longer contracts.

If the hedging pressure theory is correct, speculators will meet the net demand for hedging in the market by taking the opposite trade taken by the surplus of hedgers. If the producers are the majority of hedgers (by volume), then there should exist a premium paid by the sellers of futures, and if the consumers are the majority of hedgers then the premium should be paid by the buyers. This does not mean that all speculators will always take the profitable side of a futures position, but that the aggregate sum of speculators in the market is collecting a risk premium paid by hedgers seeking to reduce spot price uncertainty. In theory, the sum of speculators should always profit. Naturally, there would be competition in the market for providing this insurance, which would drive the premiums down. Following the CAPM model, speculators can eliminate their idiosyncratic risk by diversifying in the overall market. Therefore, competition should drive premiums down to a level corresponding to the systematic risk in the market. However, our results indicate that there is no correlation between the returns of salmon futures and that of the market. This should result in the premiums being close to zero, but they are not. Hence, our results indicate that the market could be inefficient, with suboptimal risk sharing.

9. Predictive model

Having identified many variables that can explain excess futures returns, we turn to specifying a simplified model that could be used to predict subsequent excess returns. We construct a factor portfolio that trades based on the predictions by the model, allowing for both long and short positions. The model is made to be as simple as possible, only including one variable per factor. The variables included will be momentum, spot volatility, the closest term structure variable and seasonality. At the end of each month *t*, the regression is performed with the information available at that time, and a prediction for the excess return at *t + 1* is made using the coefficients from the model. If the prediction is positive, a long position in the front month contract is taken, otherwise a short position is taken in the same contract. The position is at the same time fully collateralized with 3-month treasury bills issued by the Norwegian Central Bank. Trading costs are accounted for. The model for excess returns is:

$$r_t^e = \alpha + \lambda m_t + \gamma v_{t-1} + \omega_3 s_{t-1,3} + \sum_{i=1}^{11} \delta_i d_{t,i} + \varepsilon_t \tag{9}$$

Conditional on the information at *t*, the regression is performed and using the coefficients from the model the predicted excess return in the following period is calculated as:

$$p_{t+1} = E(r_{t+1}^e) = \alpha + \lambda r_t + \gamma v_t + \omega_3 s_{t,3} + \sum_{i=1}^{11} \delta_i d_{t+1,i} \tag{10}$$

Our data allows us to perform the required regressions beginning in June 2008, making it possible to construct the factor portfolio at that time. When we regress the excess return, r_t^e, on the lagged predictions from the model, p_{t-1}, we find a positive significant correlation[15]. R^2 is close to 10% which means that at least some variance in the excess returns can be predicted by the model. Hence, any investor basing their investment decisions on these predictions should

[15] See Appendix 2 for regression table.

outperform the passive long investor in the market. Consistent with this theory, we find that the factor portfolio significantly outperforms the passive portfolio. In fact, the portfolio outperforms just about any other asset we have compared it to. Furthermore, the portfolio should over time become better at predicting subsequent returns, as the information set available becomes larger. This seems to be the case, as can be seen in figure 3 below.

Figure 3: Returns of the factor portfolio compared to returns of the passive portfolio.

The passive portfolio had an arithmetic average annual return below that of the market in the period 2008 - 2019, at 9.4%. It also had a yearly standard deviation of 44.2%, offering a very poor return to risk ratio. However, the factor portfolio had an average return of 29.8%. It still had significant volatility, with a yearly standard deviation of 35.1%. Nonetheless, as can be seen in both table 2 and 3, a portfolio based on the factors identified in this paper can significantly outperform the passive investor.

Table 2: Yearly returns, November 2008 – November 2019

Variable	Obs.	Mean	Std.Dev.	Min	Max
Factor	11	.298	.351	-.132	.926
Passive	11	.094	.442	-.45	1.018
Spot	11	.107	.253	-.332	.477
Market	11	.106	.086	-.031	.212
S&P GSCI	11	-.027	.108	-.212	.104
LBM Gold	11	.095	.153	-.215	.33
FTSE Global	11	.149	.12	-.075	.342
BB Global	11	.063	.08	-.046	.193
MSCI Real Estate	11	.159	.129	-.079	.323

Table 3: Total return, June 2008 – November 2019, %

	Factor	Passive	Spot	Market	S&P GSCI	LBM Gold	FTSE Global	BB Global	MSCI RE
Return	1410	23	122	223	-58	197	274	151	273

Table 4 shows that both the factor portfolio and the passive portfolio have very low correlations to other asset classes. This is also true for the spot price. These results indicate that salmon futures can offer good diversification effects for investors. If we regress the returns of the salmon futures portfolios on the market return, we also see that there are no significant relationships, which can be seen in table 5. This supports our conclusion that there is no systematic risk in the salmon market. Furthermore, the correlation between the portfolios are even negative, and close to zero, at -4%. The correlation between the passive portfolio and the spot price is quite significant at 54%. The asset with the highest correlation with the factor portfolio in absolute terms is gold, with a correlation of -19%.

Table 4: Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Factor	1.00								
(2) Passive	-0.04	1.00							
(3) Spot	0.05	0.54	1.00						
(4) Market	0.02	0.05	0.06	1.00					
(5) S&P GSCI	-0.09	0.09	0.05	0.04	1.00				
(6) LBM Gold	-0.19	-0.11	-0.04	0.29	-0.04	1.00			
(7) FTSE Global	0.06	0.09	0.12	0.72	0.36	-0.10	1.00		
(8) BB Global	-0.03	-0.00	-0.02	0.74	-0.29	0.49	0.07	1.00	
(9) MSCI RE	0.09	0.09	0.09	0.71	0.20	0.01	0.81	0.21	1.00

Table 5: Regression results

	(1) Factor return	(2) Passive return
Market return	0.0628	0.147
	(0.26)	(0.57)
Constant	0.0211***	0.00212
	(3.47)	(0.33)
N	136	136
R^2	0.0005	0.0024

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

10. Trading costs and liquidity constraints

As we have not been able to obtain data for historical brokerage/trading costs, we have been forced to use a cost estimate to calculate the returns of our portfolios. Total variable trading costs at Fish Pool amount to 0.185 NOK/kg. However, there are many ways to get discounts. For example, exiting a contract within one month of entering it allows for no variable trading costs. Also, trading a strategy gives a 50% reduction of the variable fees. We have used the latter as an estimate for the entire period. As such, our portfolios pay 0.0925 NOK/kg for the contracts they exit or enter. Monthly rolling requires brokerage fees to be paid twice at the end of each month. An investor seeking to reduce transaction costs could, in theory, construct a portfolio which rolls contracts less frequently, perhaps every second or third month. Such an investor would naturally also have to consider other factors such as reduced liquidity. Furthermore, we have not accounted for trading costs related to the hedged positions in treasury bills, because it has been difficult to come up with a correct estimate for the associated costs. Nonetheless, any investor seeking to hedge their positions with an asset yielding the risk-free rate of return could almost replicate it by bank deposits. There is also the fact that the share of the total return of the hedged factor portfolio associated with holding treasury bills is only 3.9%.

As indicated by Bloznelis (2018) and Asche et al. (2016a), liquidity is an issue in the market for salmon futures. However, in constructing our portfolios, we consistently focus on the shortest-term contracts, which are the most liquid (Andersen 2019, Asche et al. 2016a, Bloznelis 2018). Furthermore, the results should not change significantly if the date of the rolling procedure differs by some days, which is a likely occurrence in a market with low liquidity. However, the minimum contract size is one ton, which at a futures price of 60 NOK/kg amounts to 60 000 NOK, a significant amount. This minimum barrier of trade can prevent many to enter the market, leaving it to large producers, consumers and financial institutions[16] and makes the contracts less liquid. Further research about the premiums related to liquidity in the salmon futures market is something we believe could have interesting results.

11. Conclusions

We find that there is a premium in the salmon futures market, which in the long run is gained by the holders of long positions in the front month contracts. This is congruent with previous

[16] See Appendix 3 for the share of trading by type of trader.

findings (Asche et al., 2016a). However, we find that when accounting for trading costs, the return on the portfolio over the sample period is negligible, amounting to a mere 9.7 % since the beginning of 2007. This still beats the S&P GSCI which has yielded roughly -35 % in the same period. Furthermore, we find mixed results for our multi-factor model for salmon futures excess returns. The estimates for both systematic risk and basis are both insignificant, indicating that there are no premiums related to these factors. These findings contradict previous research on salmon futures which find that the basis is related to premiums (Asche et al., 2016a). Furthermore, our findings contradict the original CAPM model which postulates that investors are only compensated for carrying systematic risk. However, our main findings are the significant factors which we show have predictive capacity in the market; momentum, spot volatility, term structure and seasonality. Constructing a rolling futures portfolio based on these factors result in a portfolio that significantly outperforms both the passive portfolio and the market, yielding over 1400% in the period from June 2008 to November 2019. Besides yielding high returns, we find that the factor portfolio has no significant systematic risk and that it exhibits very low correlations to all other asset classes included in our dataset. However, we speculate that low liquidity could prevent investors in realizing the full potential of the predictive capabilities in the market.

12. References

Andersen, Bendik Persch (2019). *Efficiency in the Atlantic Salmon Futures Market.* NTNU.

Asche, Frank and Misund, Bård (2016) *Hedging Efficiency of Atlantic Salmon Futures.* Aquaculture Economics & Management.

Asche, Frank and Misund, Bård and Oglend, Atle (2016a). *Determinants of the Atlantic salmon futures risk premium.* Journal of Commodity Markets.

Asche, Frank and Misund, Bård and Oglend, Atle (2016b). *The spot-forward relationship in the Atlantic salmon market.* Aquaculture Economics & Management.

Asche, Frank, and Oglend, Atle and Zhang, Dengjun (2015). *Hoarding the Herd: The Convenience of Productive Stocks*. The Journal of Futures Markets.

Bakshi, Gurdip and Gao Bakshi, Xiaohui and Rossi, Alberto (2015) *Understanding the Sources of Risk Underlying the Cross-Section of Commodity Returns*. Working Paper, University of Maryland. Forthcoming, Management Science.

Basu, Devraj and Miffre, Joëlle (2013). *Capturing the risk premium of commodity futures: The role of hedging pressure*. Journal of Banking & Finance.

Bessembinder, Hendrik, (1992). *Systematic Risk, Hedging Pressure, and Risk Premiums in Futures Markets.* The Review of Financial Studies.

Bhardwaj, Geetesh and Gorton, Gary B. and Rouwenhorst, K. Geert. (2015). *Facts and Fantasies About Commodity Futures Ten Years Later*. National Bureau of Economic Research, Inc.

Bloznelis, Daumantas (2018). *Hedging salmon price risk.* Aquaculture Economics & Management

Bodie, Zvi and Rosansky, Victor I. (1980). *Risk and Return in Commodity Futures*. Financial Analysts Journal.

Brennan, Michael J. (1958). *The Supply of Storage.* The American Economic Review.

Carter, Colin A. and Rausser, Gordon and Schmitz, Andrew (1983). *Efficient Asset Portfolios and the Theory of Normal Backwardation.* Journal of Political Economy.

Chan, Wing H. and Chong, Terence T.L. and Tsui, Chun (2017). *Factor pricing in commodity futures and the role of liquidity*. Quantitative Finance.

Chan, Wing H. and Shelton, Bryce and Wu, Yan W. (2018). *Volatility Spillovers Arising from the Financialization of Commodities.* Journal of Risk and Financial Management.

Chang, Eric C., Chen, Chao, & Chen, Son-Nan (1990). *Risk and Return in Copper, Platinum, and Silver Futures.* Journal of Futures Markets.

Chen, Xing and Scholtens, Bert (2019). *The spot-forward relationship in the Atlantic salmon market*. Reviews in Fisheries Science & Aquaculture.

Cootner, Paul H. (1960). *Returns to speculators: Telser vs. Keynes*. Journal of Political Economy.

De Roon, Frans A. and Nijman, Theo E. and Szymanowska, Marta and Van Den Goorbergh, Rob (2014). *An anatomy of commodity futures risk premia*. Journal of Finance.

De Roon, Frans A. and Nijman, Theo E. and Veld, Chris (2000). *Hedging Pressure Effects in Futures Markets.* The Journal of Finance.

Dhume, Deepa (2010). *Using Durable Consumption Risk to Explain Commodities Returns*. Harvard University.

Doeswijk, Ronald and Lam, Trevin and Swinkels, Laurens (2019) *Historical Returns of the Market Portfolio*. The Review of Asset Pricing Studies.

Dusak, Katherine (1973). *Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums.* Journal of Political Economy.

Eagleeye, Joseph and Till, Hilary (2003). *Commodity Investing Risks.* SSRN Electronic Journal.

Erb, Claude B. and Harvey, Campbell R. (2006). *The Strategic and Tactical Value of Commodity Futures.* Financial Analysts Journal.

Ewald, Christian-Oliver and Ouyang, Ruolan (2017) *An analysis of the fish pool market in the context of seasonality and stochastic convenience yield*. Marine Resource Economics.

Ewald, Christian-Oliver and Salehi, Pariya (2015). *Salmon Futures and the Fish Pool Market in the Context of the CAPM and the Fama & French Three-Factor Model*. SSRN Electronic Journal.

Fish Pool (2019) About Fish Pool ASA. Available at: http://fishpool.eu/about/ (19.12.2019)

Fuertes, Ana-Maria and Miffre, Joëlle and Perez, Adrian F. (2016). *Is Idiosyncratic Volatility Priced in Commodity Futures Markets?* International Review of Financial Analysis, 2016.

Gorton, Gary and Rouwenhorst, K. Geert (2006) *Facts and Fantasies about Commodity Futures*. Financial Analysts Journal.

Gorton, Gary and Hayashi, Fumio and Rouwenhorst, K. Geert (2013). *The Fundamentals of Commodity Futures Returns.* Review of Finance

Harper, David R. (2019). *Contango vs. Normal Backwardation: What's the Difference?* Available at: https://www.investopedia.com/articles/07/contango_backwardation.asp (19.12.2019)

Hicks, John Richard (1939) *Value and Capital: An inquiry into some fundamental principles of economic theory*. Oxford, UK: Clarendon Press.

Hirshleifer, David (1988) *Residual Risk, Trading Costs, and Commodity Futures Risk Premia.* Review of Financial Studies.

Hirshleifer, David (1990) *Hedging Pressure and Futures Price Movements in a General Equilibrium Model.* Econometrica.

Hong, Harrison and Yogo, Motohiro (2012). *What does futures market interest tell us about the macroeconomy and asset prices?* Journal of Financial Economics.

Irwin, Scott H. and Sanders, Dwight R. and Smith, Aaron and Main, Scott (2019). *Returns to Investing in Commodity Futures: Separating the Wheat from the Chaff.* Working paper, University of Illinois.

Kaldor, Nicholas (1939). *Speculation and Economic Stability*. Review of Economic Studies.

Keynes, John M. (1930) *A Treatise on Money, vol 2*. London: Macmillan.

Khan, Saqib A. and Khokher, Zeigham and Simin, Timothy T. (2008). *Expected Commodity Futures Returns.* SSRN Electronic Journal.

Miffre, *Joëlle* and Rallis, Georgios. (2007) *Momentum Strategies in Commodity Futures Markets*. Journal of Banking and Finance.

Mitchell, Cory (2019) *Inverted Market.* Available at: https://www.investopedia.com/terms/i/invertedmarket.asp (19.12.2019)

Mowi (2019) *Salmon Farming Industry Handbook 2019*. Available at : https://mowi.com/investors/resources/ (19.12.2019)

Norges Bank (2019a) *Rentestatistikk*. Available at: https://www.norges-bank.no/tema/Statistikk/Rentestatistikk/ (19.12.2019)

Norges Bank (2019b). *Valutakurser.* Available at: https://www.norges-bank.no/tema/Statistikk/Valutakurser/ (19.12.2019)

Norwegian Seafood Council (2019) *Norwegian seafood exports total NOK 99 billion in 2018*. Available at: https://en.seafood.no/news-and-media/news-archive/norwegian-seafood-exports-total-nok-99-billion-in-2018/ (19.12.2019)

Sakkas, Athanasios and Tessaromatis, Nikolaos (2019). *Factor Based Commodity Investing.* Working paper. SSRN.

Tang, Ke and Xiong, Wai (2010). *Index Investment and Financialization of Commodities*. Financial Analysts Journal.

Telser, Lester G. (1958). *Futures Trading and the Storage of Cotton and Wheat*. Journal of Political Economy.

Working, Holbrook (1949) *The Theory of the Price of Storage*. American Economic Review.

Yang, Fan (2013). *Investment shocks and the commodity basis spread.* Journal of Financial Economics.

Yogo, Motohiro (2006). *A Consumption-Based Explanation of Expected Stock Returns.* The Journal of Finance.

Appendix 1: Definitions and clarifications

Contract definitions

Fish Pool futures contracts utilize the monthly Fish Pool Index (FPI) spot price as the underlying benchmark for settlements. The contract month is referred to the month which the contract bases its settlement upon. A futures contract for March uses the monthly average FPI for March as settlement and is thus a March contract. The contract will expire in the second week in the month following the contract month. A March contract will expire in April. However, for all practical purposes we will in this paper refer to the contract month as the expiration month. This is because the settlement price is based upon an average price and we want to eliminate any effects this could cause when holding a contract in its contract month. A front month contract for March would as such be entered in the end of January and held until the end of February.

Hedged positions

When entering a futures contract at Fish Pool, there is a capital requirement which would make up a portion of the contract. Ignoring capital requirements and assuming a fully hedged position in 3-month treasury bills issued by the Norwegian Central Bank makes the returns comparable to that of other un-leveraged assets. This increases the interest gained from hedged position compared to reality, but it is difficult to quantify the portion of the contract value which makes up the total capital requirement. Also, the interest gained from risk free assets in the period is relatively small. Furthermore, this is the procedure presented in Gorton and Rouwenhorst (2006) which we replicate.

Rolling portfolio returns

Constructing a hedged rolling portfolio of front month contracts involves a lot of trading. Here is an illustrative example: A long position in a front month contract for 1 kg for March at 25

NOK is entered at the end of January. This incurs a trading cost of 0.0925 NOK/kg, which makes the value of the portfolio before trading 25.0925 NOK. At the same time the full value of the position, 25 NOK, is hedged in 3-month treasury bills. At the end of February, the contract for March is worth 26 NOK. The contract is sold, giving 1 NOK in excess returns, which after trading costs amount to 0.9075 NOK. The hedged position in treasury bills is also sold and leaving 0.125 NOK in interest gained. The total value of the portfolio is now 25 NOK + 0.9075 NOK + 0.125 NOK = 26.0325 NOK. The next front month contract is April, which is trading at 26 NOK as well. When accounting for trading costs, the number of April contracts which can be entered is:

$$N = \frac{V}{P - C}$$

where V is the value of the portfolio at the end of the month, P is the price of the contract and C is the trading cost of entering one contract. At the current price the number of contracts to be entered is 26.0325/26.0925 = 0.9977, leaving the value of the portfolio to 25.94, which is hedged using treasury bills, and the procedure is repeated.

Member costs at Fish Pool and Nasdaq Clearing

When trading at Fish Pool, one incurs both variable and fixed costs[17]. Fixed costs amount to 50 000 NOK annually. Variable fees for Fish Pool are 0.1 NOK/kg and 0.085 NOK/kg for Nasdaq Clearing. There are volume discounts of 30% for the variable fees given for members trading over 20 000 tons. Financial institutions get a discount, making variable fees totaling 0.13 NOK/kg. Customers/speculators trading a strategy get a 50% discount of the variable fees, and customers exiting a position within one month of entering it, get the total amount of variable fees reimbursed.

[17] Fee list is obtained from Fish Pool, Dec. 2019: http://fishpool.eu/trading/fee-list/

Denominations

Unless otherwise specified, all values and returns are denoted in NOK.

Contract size

Minimum contract size is one ton. Therefore, managing to enter the exact number of contracts in the front month contract as stipulated by the rolling procedure would be a difficult task. However, an investor trading large volumes could still closely duplicate a rolling portfolio following the principles presented in this paper. Investors trading smaller volumes should also be able to outperform passive long investment by having exposure to the factors we have identified.

Appendix 2: Regression tables and diagnostic tests.

Table 1: Regression Table

	(1)
	Excess Return
Excess Return Prediction	0.386***
	(3.83)
Constant	0.00516
	(0.89)
N	137
R^2	0.0978

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Diagnostic tests for original specification:

Durbin's alternative test for autocorrelation

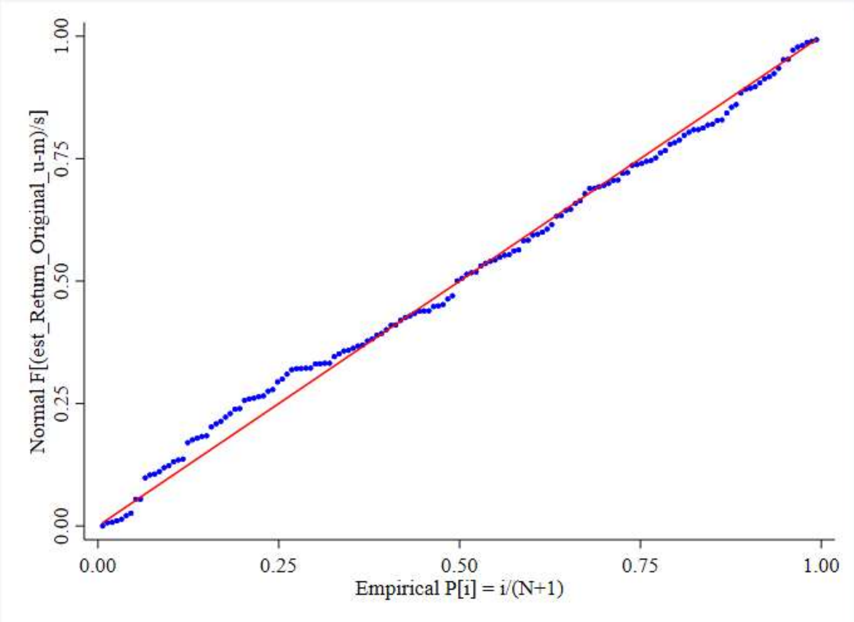
Chi^2	df	Prob>Chi2
1.619	1	0.203

H0: no serial correlation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of Excess Return
chi2(1) = 3.81
Prob > chi2 = 0.0508

Ramsey RESET test using powers of the fitted values of Excess Return
Ho: model has no omitted variables
F(3, 129) = 3.30
Prob > F = 0.0224

Residual plot for original specification:



Diagnostic tests for specification 1:

Durbin's alternative test for autocorrelation

Chi2	df	Prob>Chi2
1.168	1	0.280

H0: no serial correlation

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of Excess Return

chi2(1) = 2.43

Prob > chi2 = 0.1188

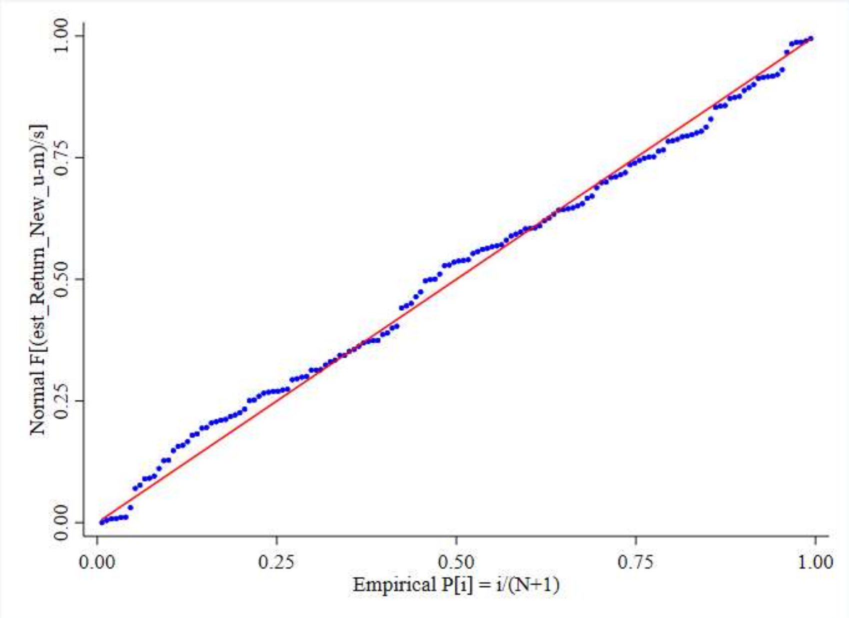
Ramsey RESET test using powers of the fitted values of Excess Return

Ho: model has no omitted variables

F(3, 122) = 0.46

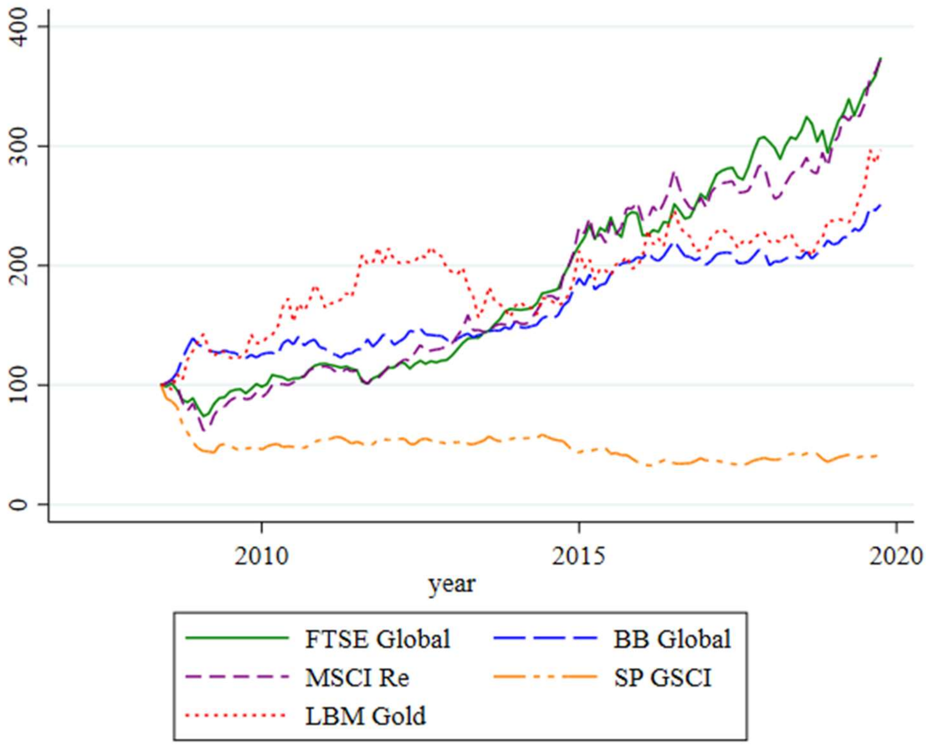
Prob > F = 0.7121

Residual plot for specification 1:

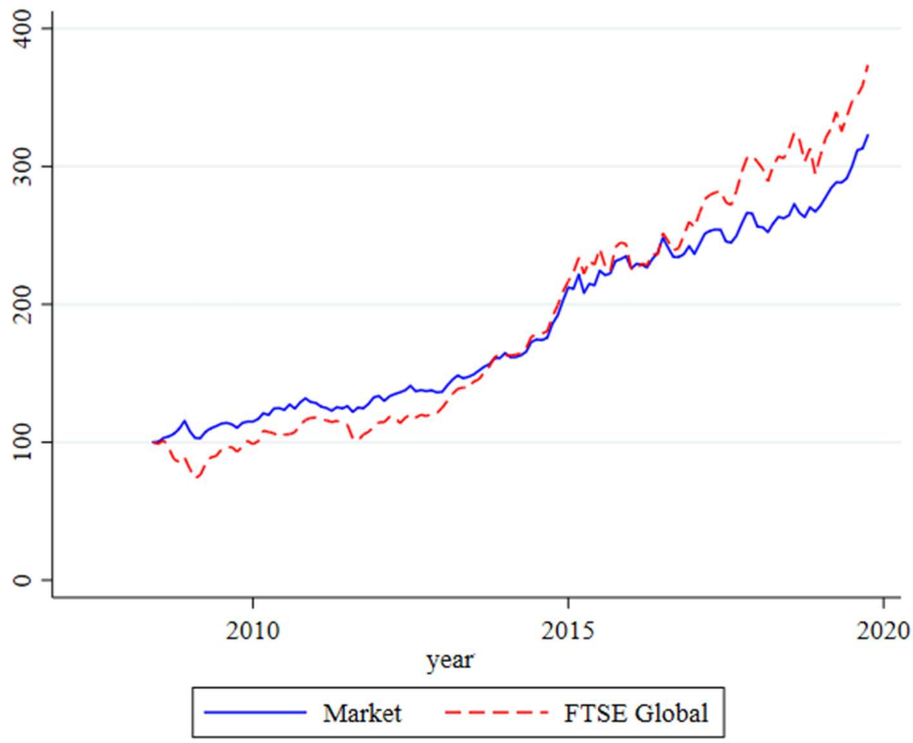


Appendix 3: Graphs.

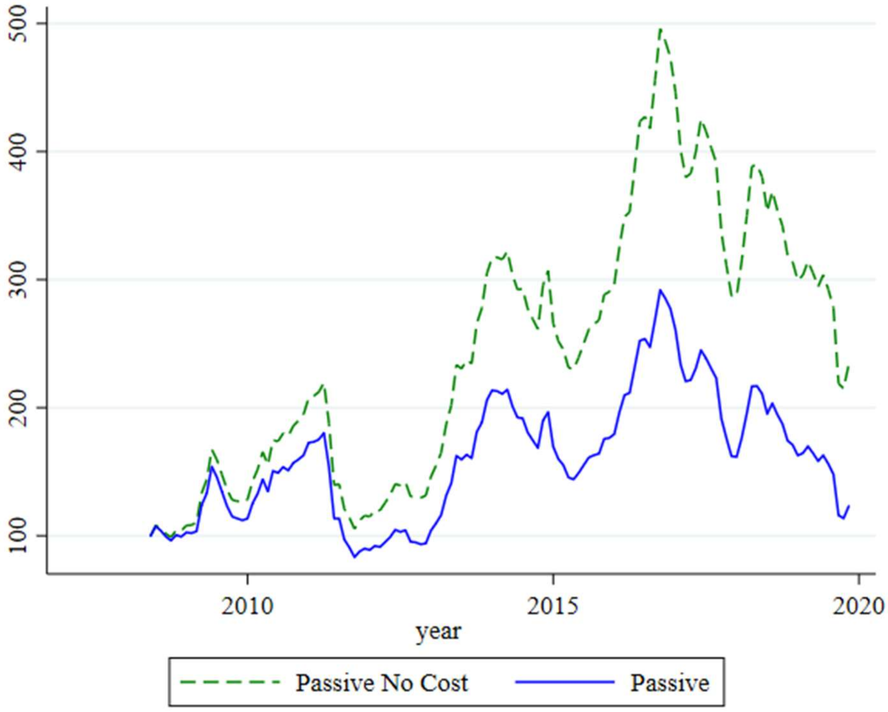
Graph 1: Returns of indices.



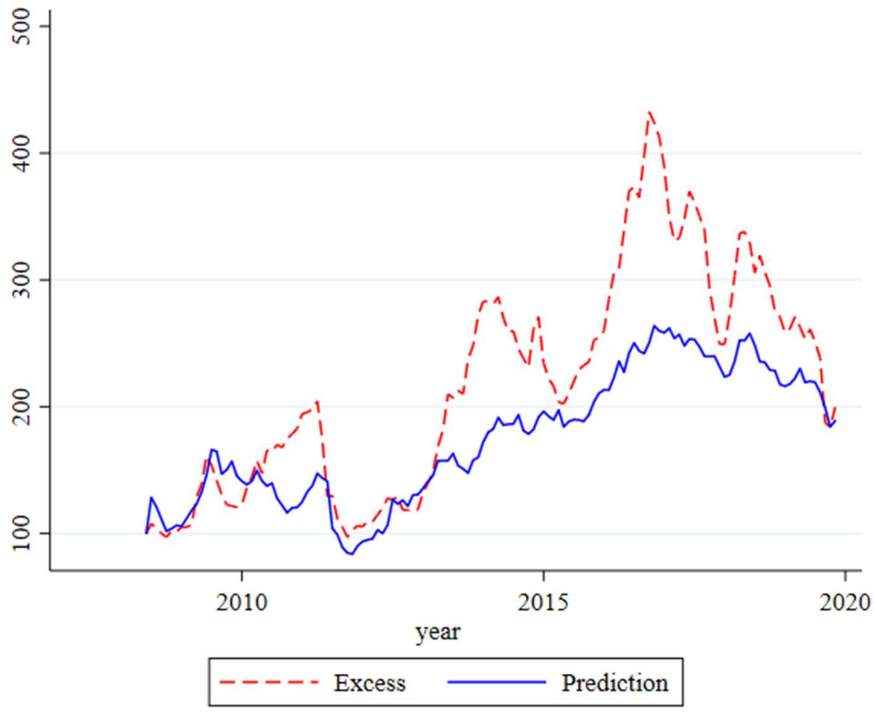
Graph 2: The market and FTSE Global All Cap.



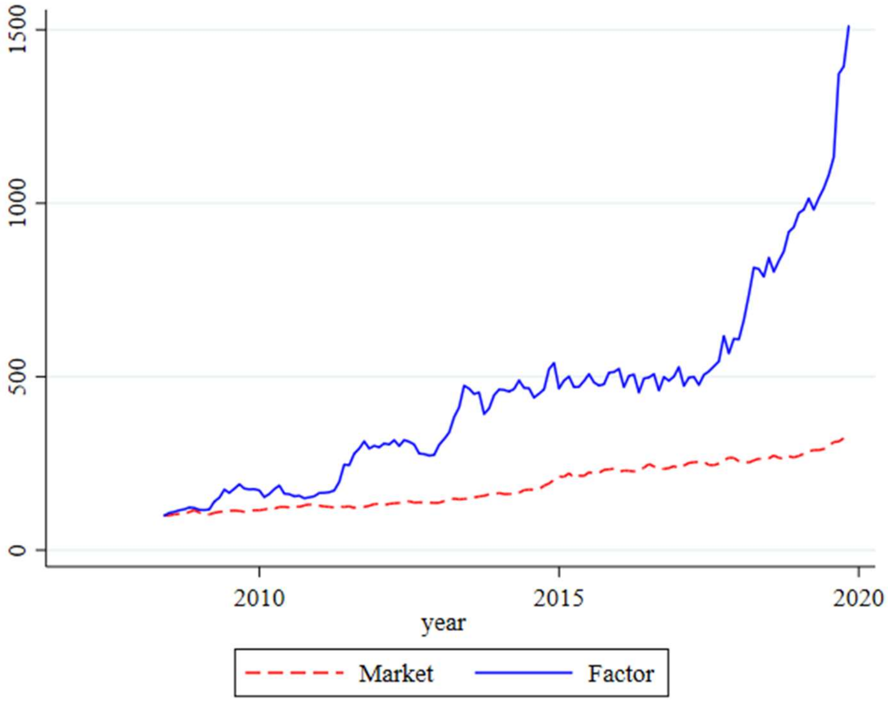
Graph 3: Passive futures portfolios with and without transaction costs.



Graph 4: Hypothetical portfolios yielding the excess returns and the predicted returns.

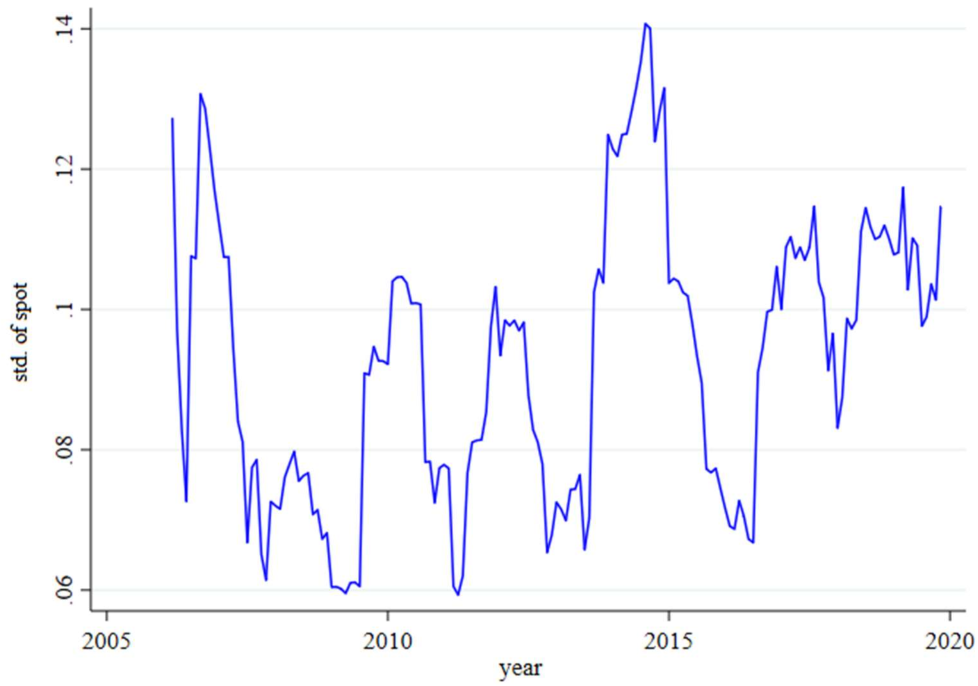


Graph 5: The factor portfolio and the market portfolio.

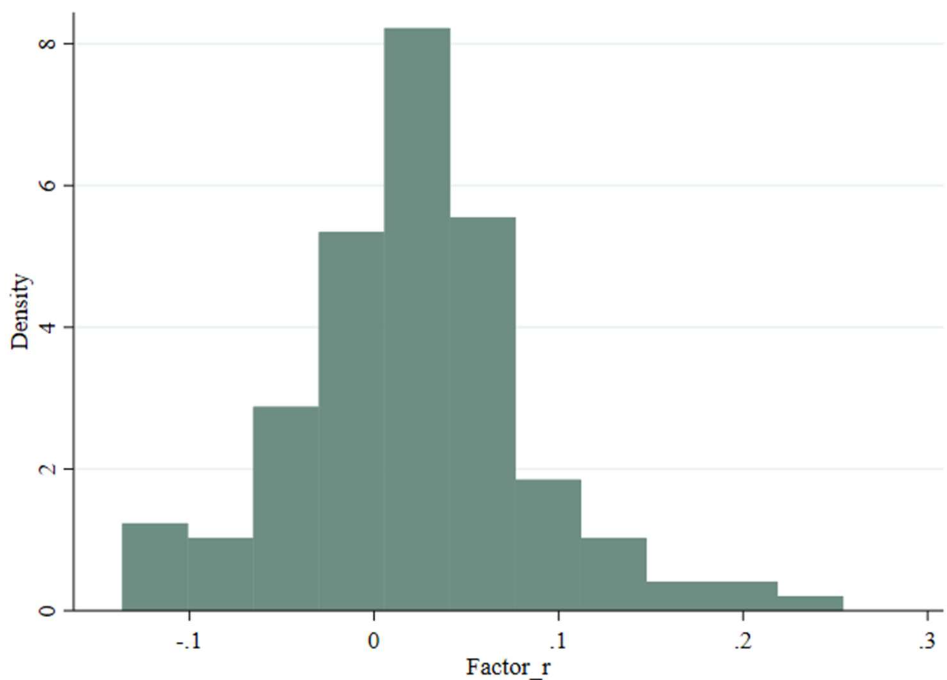


Graph 6: The passive portfolio and the market portfolio.

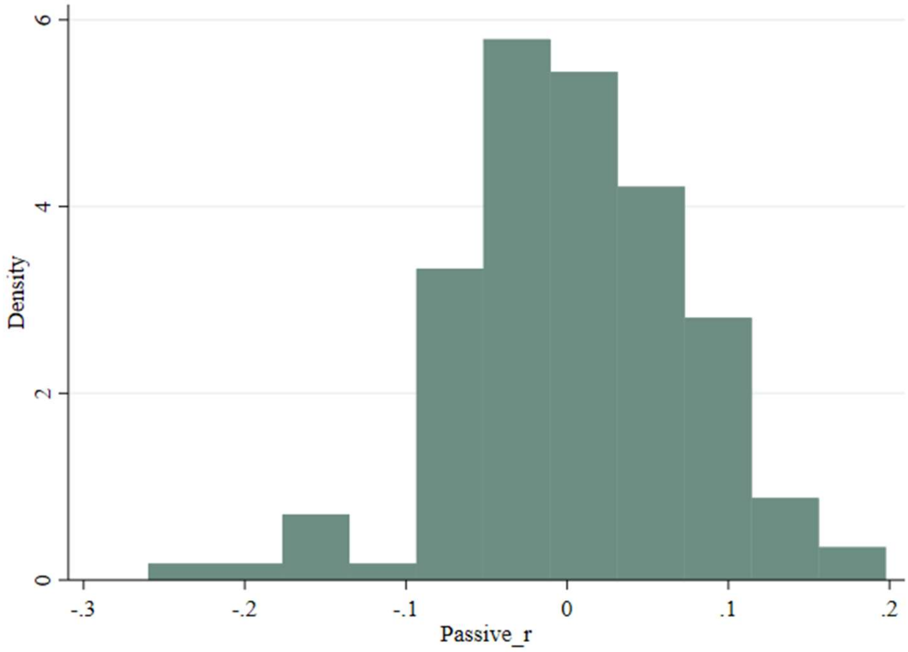
Graph 7: Standard deviation of last 12 months for FPI monthly spot price.



Graph 8: Return distribution of the factor portfolio.



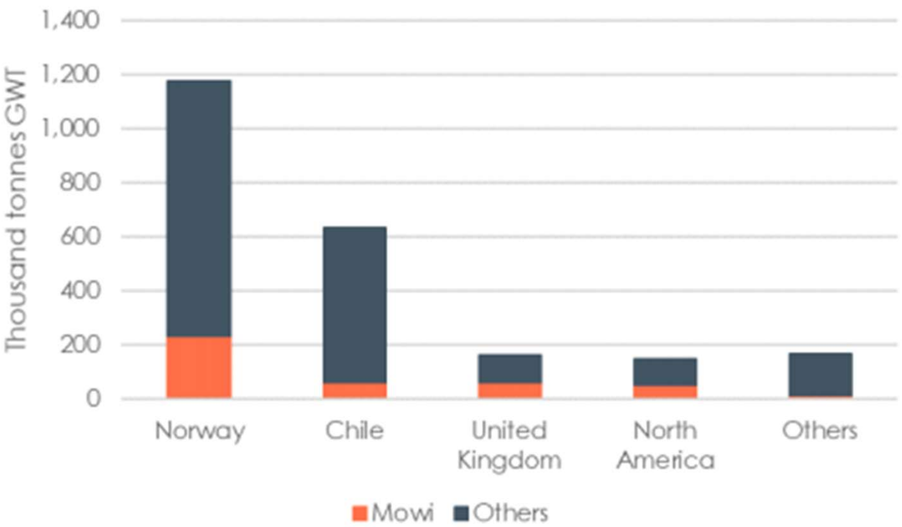
Graph 9: Return distribution of the passive portfolio.



Appendix 4: The salmon market[18]

Figure 1: Salmon world production, 2009 - 2018

Figure 2: World production volume estimates 2019.



[18] All figures in this appendix are obtained from Mowi (2019).

Figure 3: Size distribution of harvest.

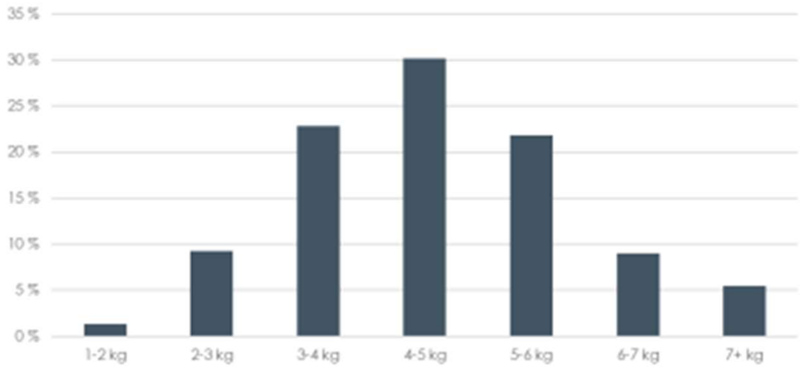
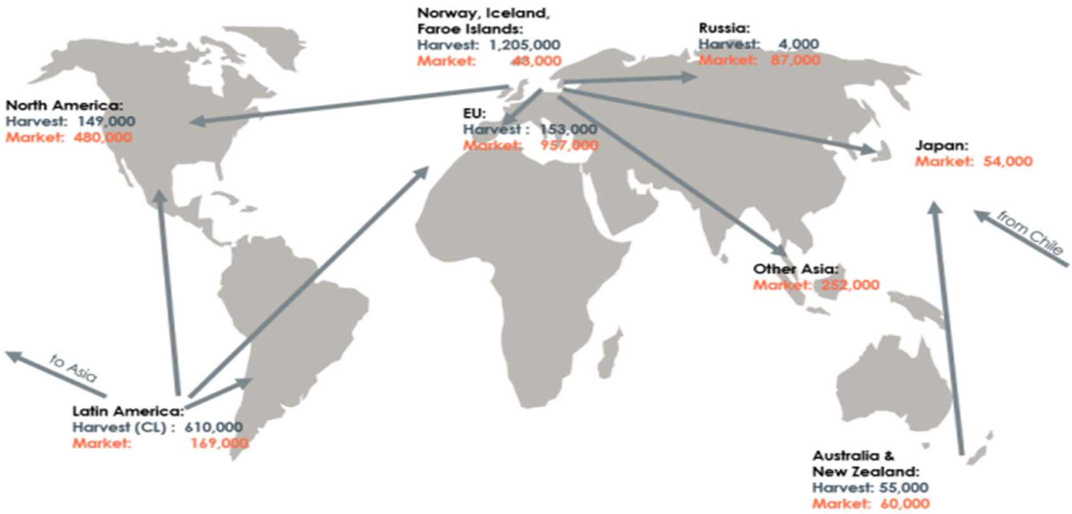


Figure 3: Global supply and demand for salmon, 2018.



Appendix 5: Data and figures

Table 1: The aggregate global investable market by asset class, weights %[19]

Year	Equities	Real Estate	Nongov Bonds	Gov Bonds	Commodities
2006	52.8	5.9	16.8	23.5	1
2007	52.1	5.4	17.6	23.7	1.2
2008	39.4	3.4	22.2	33.5	1.5
2009	41.1	3.9	21.8	31.5	1.7
2010	41.5	4.2	20.1	32.2	2
2011	38.2	4.4	20.7	34.5	2.3
2012	38.7	4.9	20.5	33.6	2.3
2013	43.4	5.2	19.5	30.3	1.6
2014	42.9	5.8	19.4	30.4	1.5
2015	42.7	5.9	19.7	30.3	1.4
2016	42.8	5.7	19.7	30.3	1.5
2017	44.7	5.7	19.1	29.1	1.5
2018	44.7	5.7	19.1	29.1	1.5
2019	44.7	5.7	19.1	29.1	1.5

[19] Doeswijk et al. (2019). Data is only up to 2017. Therefore, we use the weights from that year for the missing years, 2018 and 2019.

Figure 1: Contango and normal backwardation[20]

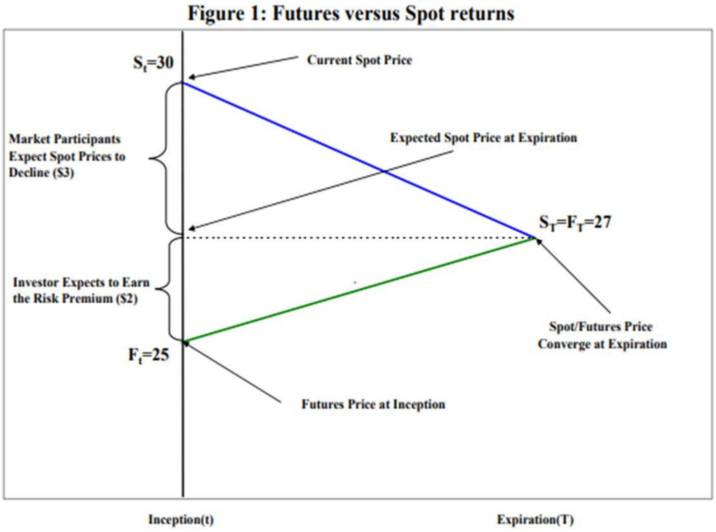
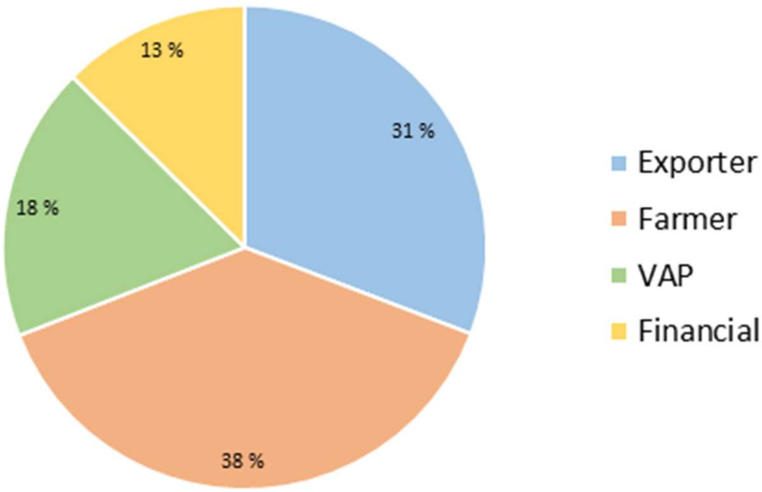


Figure 2: Volume share at Fish Pool by segment, 2018[21]



VAP = Value added product/processing. Exporters are primarily buyers of fish in the spot market as they sell fish at fixed price contracts. Hence, they are usually long hedgers in the futures market. A very rough estimate of the market participants for 2018 will be 49% long hedgers, 38% short hedgers and 13% speculators. This corresponds well to the fact that the market was in contango for most of 2018.

[20] Source: Gorton and Rouwenhorst (2006)

[21] Source: Fish Pool ASA