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Salmon futures and the Fish Pool market in the context of the CAPM and a three-factor model

Christian-Oliver Ewald[a,b], Erik Haugom[b], Leslie Kanthan[c], Gudbrand Lien[b], Pariya Salehi[c], and Ståle Størdal[b]

[a]Adam Smith Business School-Economics, University of Glasgow, Glasgow, UK; [b]School of Business and Social Sciences, Inland Norway University of Applied Sciences, Lillehammer, Norway; [c]Department of Computer Science, University College London, London, UK

ABSTRACT
Futures on fresh farmed salmon traded at the Fish Pool market in Norway are analyzed in the context of the Capital Asset Pricing Model (CAPM) and a corresponding three-factor model where contracts are separated based on their maturities. Looking into 1 month; 6 months and 12 months contracts, we find that all alphas and most betas are statistically insignificant. We conclude that the CAPM equilibrium condition holds and that Salmon futures prices move largely uncorrelated with the market portfolio and therefore offer no systematic risk premium. The latter documents that Fish Pool futures should be considered as a pure hedging instrument rather than an investment asset.

KEYWORDS
Aquaculture; CAPM; futures markets

JEL CLASSIFICATION
G13; G14

Introduction

Atlantic farmed salmon is a globally traded commodity that has experienced tremendous growth over the last two decades, both in supply and demand. Price volatility remains an issue of significant importance, both from an academic and practical point of view. Oglend (2013), Bloznelis (2016) and Asche et al. (2019) investigate the causes for recent increases in salmon price volatility. Given that salmon price is highly volatile, risk management is a continuous challenge for all parties involved in trading this commodity. Moreover, the lack of predictability in prices makes investment and operational activities that require a long-term perspective a difficult task. Hence futures contracts, play a relevant role in the industry for risk management and operational activities. According to Ankamah-Yeboah et al. (2017) the volume of salmon futures contracts traded at Fish Pool in 2014 corresponds to 9% of the total Norwegian production.

CONTACT Christian-Oliver Ewald Christian.Ewald@glasgow.ac.uk Adam Smith Business School-Economics, University of Glasgow, Glasgow, G12 8QQ, UK.

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The Norwegian Fish Pool market offers an opportunity for investors, through futures contracts with varying time horizons, to hedge their production according to their risk preferences. However, for the market to be attractive for the purpose of risk management, it must prove efficient in the sense that prices meet some form of equilibrium condition which manifests itself in a no-arbitrage condition. This article examines the latter in the context of well-known theories of market efficiency, the Capital Asset Pricing Model (CAPM) and related multi-factor models. Our analysis benefits from previous academic literature focusing on the Fish Pool market, in particular, Asche et al. (2016b), Oglend et al. (2021) and Oglend and Straume (2020) who show that bilateral salmon transaction prices have a high degree of common pricing and are well represented by the Fish Pool price index underlying the futures contracts. Their results strengthen the relevance of the futures market for hedging salmon transactions. It is further helpful in our context that recent results by Landazuri-Tveteraas et al. (2021) and Salazar and Dresdner (2021) present strong evidence for market integration in the salmon market and the hypothesis that there is in fact a global market for salmon.

Market efficiency is often described as the property that market prices correctly reflect all relevant information, but this is only half the truth. More precisely, a market is efficient (according to the semi-strong version of the efficient market hypothesis), if it is not possible to generate abnormal returns from a trading strategy that facilitates all public information. Abnormal returns are returns that break the equilibrium condition of the market. In the most general framework these would relate to arbitrages, and there is a rich literature in Mathematical Finance how this connects to the existence of martingale measures and the no-arbitrage principle.

In the CAPM, an equilibrium model which is characterized by the assumption of quadratic risk preferences and normally distributed assets returns, a violation of the equilibrium condition is reflected in alpha's which are significantly different from zero. A positive and significant alpha obtained from a strategy investing into salmon futures contract's using a margin and money market account would therefore indicate that the Fish Pool market is not efficient, at least under the assumptions of the CAPM. In addition, the CAPM also helps to understand risk-premia better. A risk-premium here is understood as the expected excess return of an asset or portfolio over the risk free rate. The CAPM indicates that the risk-premium should be proportional to the asset's or portfolio's exposure to systematic risk, measured through its correlation with the market portfolio. Idiosyncratic risk is not priced, as it is fully diversifiable, at least under the CAPM assumptions.

Trading in futures contracts should therefore provide investors with a risk premium as long as the future's returns are correlated with the market.

This is the case for crude-oil for example, see Ewald et al. (2021). For salmon futures contracts this is not clear. Ankamah-Yeboah et al. (2017) looked at risk premia (among other things) using various econometric models, but none of their models is controlling for market risk. The CAPM does this exclusively. Related multi-factor models discussed in the later parts of this article control for further factors.

In theory, risk-premia (and in consequence the returns of a futures trading strategy) could take a wide range of values without violating the no-arbitrage condition and market efficiency. In practice risk-premia are determined in equilibrium by supply and demand of futures contracts. In a futures markets where short hedgers and long hedgers are equally diversified one would expect risk-premia to be zero. However, investors and speculators are in general better diversified and require risk premia on their investment, as they have access to a wide range of investment opportunities. We refer to Misund and Asche (2016), Schütz and Westgaard (2018) and Haarstad et al. (2021) for further results that are relevant in the context of hedging salmon.

The same applies to consumers or processing companies who are in general better able to shift consumption to a substitute. As investors, speculators, consumers and processors usually take long positions, while producers take short positions, the risk-premium often shifts into a direction, where futures prices are in average below spot prices at maturity, which is often referred to as a bias. It is important to say though that this fact is not a contradiction to the no-arbitrage principle or market efficiency, but a consequence of the pricing measure (also referred to as market measure or martingale measure) being different from the real world measure (also referred to physical or statistical measure) due to the market participants risk-preferences.

To assess these effects in the context of the Fish Pool market it is important to know who participates in the Fish Pool market. Ankamah-Yeboah et al. (2017) state that Fish Pool has over 200 registered trade members and that trade volume is shared between farmers (33%), exporters/importers (14%), value added processors (23%) and financial investors (30%). While the share of financial investors (30%) is quite significant, our analysis finds that the CAPM beta measuring the correlation between futures returns and market returns is zero and so is the CAPM alpha measuring abnormal returns. In consequence we find that salmon futures risk premia are zero when controlling for market risk and that there is no indication of a violation of the CAPM equilibrium condition or market efficiency.

While the CAPM has been primarily designed to value equity, it has in the past also been applied very successfully to commodities. One would indeed expect salmon prices to feed into the prices of equity such as MOWI (formerly Marin Harvest ASA) and the Scottish Salmon Company (SSC) and therefore at least partially reflect a capital equilibrium condition. Note that in 2014 MOWI alone has been responsible for close to one fifth of the total world production of farmed salmon, see Ankamah-Yeboah et al. (2017). The CAPM's applicability to commodity futures has been widely discussed in Dusak (1973), Carter et al. (1983) and Baxter et al. (1985) and more recently in Cortazar et al. (2013).

As we will demonstrate, the application of these theories is not straightforward, neither is the estimation. The main contribution of the current article is an assessment of the validity, applicability and implementation of the CAPM and a related three factor methodology in the context of the relatively recent Fish Pool futures market. In consequence, it also presents an assessment of the market efficiency of this market. Farmed salmon is a commodity which in many ways is similar to agricultural commodities. In this aspect, our study is linked to the studies by Dusak (1973), Carter et al. (1983) and Baxter et al. (1985). In addition, we investigate the role of the share prices of the two main market players in the salmon farming business, MOWI and the Scottish Salmon Company, within the context of the Fish Pool market. Further, by sorting futures contracts by their maturity terms, the exclusivity of the information contained in different maturities is tested. Our large sample of weekly prices reduces the problem of measurement bias, historical blur and non-synchronic data.

The CAPM is a relatively simple equilibrium model and has been around for a long time but is still considered as one of the benchmark valuation models. Hollstein et al. (2020) show that it is in no way outdated. Application of the CAPM to commodity futures requires some modification. Firstly, the value of a futures contract is zero at the beginning of each day which leads to difficulties in the computation of returns, which are central to the CAPM. Secondly, the difficulties involved in the construction of the market proxy such as decisions about the inclusion of commodities; the dividend component of returns and the subsequent weights of each component has been a central controversy. Thirdly, there have been questions regarding the validity of assuming net long investors throughout the life of a futures contract as an implicit but perhaps strong assumption.

In addition to these specific problems regarding the application of the CAPM to futures contracts, any known weaknesses of the empirical performance of the CAPM on application to stocks and bonds remain relevant to the current study and will not be resolved. We do not claim that the CAPM or our related three-factor model are the best models to explain returns in salmon futures, indeed there are other models such as Ewald et al. (2017) and Chen and Ewald (2017) which are better suited.

Nevertheless, the question of whether the Fish Pool futures market is efficient in the CAPM sense is important and relevant and deserves to be looked at in detail. Market efficiency has been at the center of many related studies. Kaminsky and Kumar (1990) have laid a foundation in the context of commodity futures markets, Kristoufek and Vosvrda (2014) provide a good overview over recent results. For a market to function and market participants to have trust in price formation and to trade on the market, a high degree of market efficiency is essential. For a relatively young market such as Fish Pool, this is even more important.

Given the inability to identify the true market portfolio, the construction of the market proxy has been a common problem in many analyses of the CAPM. This has resulted in questions regarding the sensitivity of the CAPM to the market proxy, such as Stambaugh (1982) who found CAPM to be insensitive to the expansion of the market proxy beyond the typical choice of common stocks to include variables such as real estate; consumer durables, government and corporate bonds, and thus have imposed further pessimism about finding a mean-variance efficient market proxy. Of course, these results should be taken with the acknowledgment that Stambaugh's (1982) market proxies are limited to US assets. However, the extension of the CAPM to the international level with the International CAPM has also shown mixed results. Fama and French (1998) provide evidence against the success of the International CAPM where the global stock market portfolio betas were found to be unable to explain high average returns observed globally on stocks with high book-to-market or earnings price ratio. Furthermore, they found that a Two Factor version of Merton's (1973) intertemporal CAPM where the two factors are the market risk and book-to-market equity is much better able to explain the general patterns in global returns. These results support the Three Factor Model developed earlier by Fama and French (1992a) in which they found beta to be less significant in explaining expected returns than market capitalization (negative effect) and book-to-market value (positive effect). The CAPM model has been criticized among others by Fama and French (1992a, 1992b, 1998, 2004) regarding market anomalies and robustness to subsamples. Although these findings were challenged more recently by studies such as Schwert's (2003) showing disappearance of these anomalies once discovered in the market and Berk (1995) proposing data snooping; measurement error and sensitivity to data frequency as alternative explanations for these anomalies within the market. The CAPM model is an equilibrium model which implies that to the extent that real markets demonstrate market inefficiency and anomalies; the CAPM is less likely to explain the data. Therefore, methods such as using dummy variables to account for certain market anomalies and periods of crisis can provide a better analysis within the context of the

CAPM. Furthermore, the equilibrium condition of the CAPM makes the analysis of a commodity such as farmed Atlantic salmon, which is in many ways like an agricultural commodity, particularly appealing, given that agricultural commodities demonstrate the highest resemblance to an equilibrium condition.

Looking into 1 month; 6 months and 12 months Fish Pool futures contracts, we find that all alphas and most betas are statistically insignificant. While we observe slightly negative alpha's in the early phases of the market, these are declining in absolute value over time, indicating a process of market maturation. In fact, we find no indication of a violation of the efficient market hypothesis and conclude that the CAPM equilibrium condition holds for the Fish Pool market. Further, salmon futures prices move largely uncorrelated with the market portfolio and therefore offer no systematic risk premium. This complements research done by Asche et al. (2016a) who looked at factors that determine the variation of realized risk premia in the Fish Pool futures market and identified seasonal patterns in the risk premium. Our results also connect the work by Ankamah-Yeboah, Nielsen and Nielsen (2017), who do not control for systematic risk and to the assessment of risk premia in commodity futures in van Huellen (2020) who has focused on the role of speculators. There are also several research articles that assess risk more generally, most notably Solibakke (2012), Dahl and Oglend (2014), Asche et al. (2015, 2017), Dahl and Jonsson (2018), Dahl and Yahya (2019) and Steen and Jacobsen (2020).

From a purely methodological point of view, our analysis differs from most of the literature above in the way that we use the general method of moments (GMM) and recursive estimation rather than linear regression (ordinary least squares, OLS), to account for violations of the standard assumption for OLS reflected by the data.

The remainder of this article is organized as follows. Section "Futures in the context of the CAPM" provides a general discussion of the analysis of commodity futures in the context of the CAPM and the implications for the model. In Section "Three-factor model," we present an analysis of salmon futures in the context of a three-factor model inspired by Fama and French (1992a). Section "Empirical analysis" includes an empirical analysis of the CAPM and the three-factor model; description of the data and the GMM results. Our main conclusions are summarized in Section "Conclusion."

Futures in the context of the CAPM

The market portfolio and its proxy

Given that the weight of each asset within the market portfolio is determined by the total monetary value it is representing relative to the whole market and that the net supply of all futures contracts written on the same underlying is always zero; futures contracts are not presented in the market portfolio. For futures contracts, every long position is offset by a corresponding short position; thus, futures contracts as Black (1976) emphasizes, are zero net aggregate supply assets. This theoretical implication questions the legitimacy of the application of the CAPM to futures contracts. Baxter et al. (1985) provide further evidence and emphasize the problem in a footnote by raising the question "does it make sense to price a non-asset (i.e. zero net supply) with the CAPM?" (p. 124).

Dusak (1973) analyses the existence of risk premia in commodity futures markets (Keynesian theory of Normal Backwardation, 1930) within the context of the CAPM and estimates systematic risk for three heavily traded agricultural commodity futures (wheat, corn and soybeans); using semi-monthly futures prices over a period of 15 years (1952–1967) where contracts are sorted seasonally (for example September contracts). Dusak (1973) found that for all three commodity futures, both systematic risk and average realized holding period returns are close to zero, despite the fact that risk measured in the "Keynesian sense" (price variability or total risk) was high and hence concluded that her sample of observations on commodity futures conformed better to the "capital markets model or the portfolio approach of risk" than to the "Keynesian insurance interpretation" (cost of insurance against price variability).

Even though, the issue of CAPM's applicability to futures contracts is not addressed explicitly by Dusak (1973); she explains "It is argued that futures markets are no different in principle from the markets for any other risky portfolio assets … .In particular, they are all candidates for inclusion in investor's portfolio … [The portfolio approach] says, rather, that returns or any risky capital asset, including futures market assets, are governed by that asset's contribution, positive, negative, or zero, to the risk of a large and well-diversified portfolio of assets (in fact, all assets, in principle)" (p. 1388).

The authors of this study are of the opinion that the futures contracts' eligibility for inclusion in investor's portfolio leads to their conformance to the CAPM theory, regardless of their exclusion from the theoretical "all wealth" and in fact their offsetting behavior in the whole market and the consequential zero net monetary value in the market portfolio is not inconsistent with the CAPM theory.

Nevertheless, the central controversy in the application of the CAPM to futures contracts is the choice of the market proxy. Dusak (1973) used the Standard & Poor's (S&P) Index of 500 industrial common stocks as proxy for the market portfolio. She argued that common stocks represent a significant amount of total wealth; so even in a more comprehensive index they would have a significant weight. The main drawback of this proxy is the absence of dividend components of return; even though due to their low variability, their omission is unlikely to have a significant effect on regression analysis.

Carter et al. (1983) criticize Dusak (1973) for using a mis-specified model due to the omission of commodities in the market portfolio proxy (in fact no US farms are traded in equity markets). They argue that Dusak's results are a result of this model misspecification as the omission of commodities from the market proxy biases the estimates toward zero and hence Dusak's statistically insignificant estimates are not surprising. Carter et al. (1983) use the same commodities that were used by Dusak (1973), but add cotton and live cattle to their sample which are more closely related to the general level of economic activity and construct an index market proxy composed of equal distribution of weight between S&P index of 500 common stocks and the Dow Jones Commodity Futures Index. Contrary to Dusak's (1973) results, Carter et al. (1983) found large positive and statistically significant betas (systematic risk) and alphas (excess/abnormal return of the asset over the risk-free rate), indicating a violation of the CAPM and supporting the generalized Keynesian normal backwardation theory. They justify the equal distribution of weight between the two indexes by the comparison of stock market value in 1977 ($950 billion) to two measures of the value of the agricultural sector in the economy; total farm assets ($650 billion) and the value of commodities represented by contracts traded in 1977 ($1,230 billion).

Marcus (1984) criticizes Carter et al. (1983) in two ways. Firstly, the inclusion of the Dow Jones Commodity Futures Index is accordingly not appropriate due to the issue of zero net supply of futures and hence these must be excluded from the market portfolio. Secondly, for the equal distribution of weight between the S&P 500 index and the Dow Jones commodity futures index in the market proxy he argues that Carter et al. (1983) have overrepresented the weight of commodities by using inappropriate measures to value commodities. In particular, the $1.2 trillion figure is likely to correspond to the sum of all trades that year rather than the more meaningful value of open interest outstanding which as listed on the Wall Street Journal (MAR 1987) amounted to only $19 billion (less than 2% of $1.2 trillion). Marcus (1984) concludes that Carter et al. (1983) have essentially regressed the commodity futures prices on an index that is dominated by those same prices and hence their results come at no surprise. Accordingly, a more reasonable weighting scheme would have resulted in much lower beta estimates.

Baxter et al. (1985) introduce a new model to replicate Dusak's (1973) work and extend on Marcus's (1984) theoretical conjecture; even so agreeing with Carter et al. (1983) about the importance of including commodities in the market portfolio. They agree that due to the zero-net supply of futures contracts, they should not be included in the market portfolio but that it is correct to include the value of cash commodities. Therefore, they build a model on the logic that only cash commodities be included in the model and hence construct a market proxy with a combination of 6.3% of the Dow Jones Commodity Cash Index and 93.7% of the S&P 500 Index. They emphasize Black's (1976) argument that "to the extent that stocks of commodities are held by corporations, they are implicitly included in the market portfolio" (p. 172) and hence argue that in constructing the market proxy, the value of futures could not be reasonably compared with that of stocks.

Furthermore, the authors of this study are of the opinion that the inclusion of commodities into the market proxy is likely to result in double counting as the prices of commodities are already incorporated into the share prices of the companies that deal with these commodities. For example, even though the price of oil may not be included in the S&P 500 Index, British Petroleum BP is and, in this case, including both would result in double counting. Indeed, Baxter et al.'s (1985) results are in line with this argument as they find similar results to Dusak (1973) even with the inclusion of cash commodities in their market proxy; indicating that the explicit inclusion of commodities into the market proxy is perhaps unnecessary. Like Dusak (1973), they find no violation of the CAPM and beta estimates that are not statistically different from zero. Furthermore, they add cotton to their sample as in Carter et al. (1983) in order to include a commodity more closely related to the general level of economic activity. They found similar results for cotton futures.

Net short investors

Another criticism of Dusak (1973) raised in Carter et al. (1983) involves the implicit assumption that investors are net long throughout the life of the futures contracts. Carter et al. (1983) relax this assumption in their study by including a variable in their model that allows for both net short and net long positions. However, this approach is disapproved of by Baxter et al. (1985) who argue that the empirical methodology of Carter et al. (1983) is inconsistent with the CAPM theory because the CAPM is a model of equilibrium in which there are no short positions and thus Dusak's (1973) approach of including the risk free rate in an equilibrium model with zero short positions is consistent with the theoretical CAPM. Furthermore, the existence of short positions in sample-efficient sets is the exact basis for the rejection of CAPM in the study by Levy (1983).

Therefore, relaxing the net long assumption is equivalent to relaxing the equilibrium assumption which is central to the CAPM theory (Baxter et al., 1985).

The model

The standard CAPM model as in Sharpe (1964) states that

$$\mathbb{E}(r_i) = r_f + \beta_i(\mathbb{E}(r_m) - r_f), \tag{1}$$

where $\mathbb{E}(r_i)$ is the expected rate of return (ex-ante) on asset *i*; $\mathbb{E}(r_m)$ is the expected rate of return on the market portfolio and beta $(\beta_i = \frac{cov(r_i, r_m)}{\sigma^2(r_m)})$ is the sensitivity of the asset's return to variations in the market return.

The application of the CAPM model to futures contracts imposes an essential modification of the CAPM model in comparison to its typical application to stocks. This modification is due to the zero initial investment requirement in futures contracts (Dusak, 1973). When an investor enters into a futures contract there is at least in theory no initial investment required. Practically margin requirements apply, however this is still very different than purchasing a stock where the transaction calls for immediate payment. A futures contract instead is an agreement to purchase (long) or sell (short) at a later date and a small fraction of the value of the contract (typically 5–10%) is deposited as a margin with the clearing house.[1] At closeout, the clearing house returns the margin plus or minus any profits or losses that occurred over the period. Futures are settled daily which means that the contract has a value of zero at the beginning of each day and is closed out at the prevailing futures price. Therefore, as opposed to stocks where the payment is made up front and hence the investor must be compensated for the time value of money r_f, here the investor does not require this compensation. However, interest can be earned on the margin deposit since any kind of collateral such as government bonds can be deposited as margin on futures positions. Dusak (1973) explains "The margin, despite surface appearances, is thus not a portfolio asset in the sense of the Sharpe general-equilibrium model, but merely a good-faith deposit to guarantee performance by the parties to the contract." She goes on to say "That entering into a futures contract need involve no margin or other specific payment that could be interpreted as an "investment" (and hence that could serve as the basis for computing a "rate of return") does not mean that the mean-variance portfolio model cannot be applied at the micro-level to analyze an investor's decision process. The price changes on the contracts held will affect *terminal* wealth, just as in the case of any other asset; but the contracts do not appear in the *initial* wealth constraint" (Dusak, 1973).[2]

Thus, hypothetical zero initial investment in futures contracts implies that we cannot express Equation (1) in percentage terms and instead Equation (1) needs to be rewritten in currency (NOK) returns as follows:

$$\mathbb{E}(p_1) - p_0 = r_f p_0 + \beta_i(\mathbb{E}(r_m) - r_f), \tag{2}$$

and

$$\beta_i = \frac{cov\ (p_1 - p_0,\ r_m)}{\sigma^2\ (r_m)}, \tag{3}$$

where p_0 is the initial price and p_1 is the final price of asset *i*. Substituting Equation (3) into Equation (2) we obtain:

$$\mathbb{E}(p_1) - p_0 = r_f p_0 + (\mathbb{E}(r_m) - r_f) \frac{cov\ (p_1 - p_0,\ r_m)}{\sigma^2\ (r_m)}. \tag{4}$$

However, since there is no initial investment in a futures contract and the value of the futures contract at the beginning of each week is zero, $p_0 = 0$ and hence p_1 is the change in the futures price over the single period, which we also denote as Δp.

Therefore, the final expression of the CAPM model for a futures contract is (compare Baxter et al. (1985) and Black (1976)):

$$\mathbb{E}(\Delta p) = (\mathbb{E}(r_m) - r_f) \frac{cov\ (\Delta p,\ r_m)}{\sigma^2\ (r_m)}. \tag{5}$$

Equation (5) states that the expected return of a futures contract is equal to the expected excess return of the market over the risk free rate multiplied by the factor beta (systematic risk) which is interpreted as the sensitivity of the contract to variations in the market. This is the CAPM model applied to futures contracts.

The absence of the risk free rate (as the compensation for time value of money for the asset) in Equation (5) has two important implications for the futures contract. Firstly, given equivalent betas, the expected return of a stock is r_f amount greater than the return for a futures contract as measured in the difference of futures prices under daily settlement. This means that a stock with comparable riskiness to that of a commodity represented by a futures contract will have a higher expected return by the amount of the risk free rate (Elam & Vaught, 1988). Secondly and more importantly for this analysis, the series of futures prices for a futures contract with zero systematic risk or equivalently with zero beta, will have no recognizable drift and mathematically presents a martingale. This is consistent with relevant results in continuous time finance, see for example Ewald and Taub

(2020). The application of the CAPM model to futures contracts implies that the expected return of a zero beta futures contract is zero.

The empirical model

The empirical equivalent of Equation (5) is sometimes called the market model. Here we add the time dimension t and the contract dimension to the model where i represents different contracts sorted by the term of maturity (1 month; 6 months and 12 months). The empirical CAPM model applied to futures is (Baxter et al., 1985):

$$r_{it} = \alpha_i + \beta_i \left(r_{mt} - r_{ft}\right) + \epsilon_{it}, \tag{6}$$

where r_{it} is the realized absolute weekly return of the futures contract identified as Δp previously; α_i is the abnormal return or the excess return of the futures contract above the asset's risk premium such that (Baxter et al., 1985):

$$\alpha_i = r_{it} - \beta_i(r_{mt} - r_{ft}) + \epsilon_{it}. \tag{7}$$

Here α_i represents a premium on unsystematic or diversifiable risk which according to the CAPM must be equal to zero. The excess return of the market over the risk-free rate (market risk premium) is $r_{mt} - r_{ft}$ and ϵ_{it} is a random disturbance.

The CAPM implies that higher returns are not possible without higher risk and that the only risk that is rewarded by a premium is the market risk, the only risk factor that a futures return should be exposed to is market risk. In other words, the beta factor (excess return of the market over the risk-free rate) must suffice in explaining the variation in the futures returns. Furthermore, if a futures contract is not exposed to market risk and hence has beta equal to zero, then its expected return is also equal to zero (since there is no compensation for time value of money r_f).

Therefore, the application of the CAPM to futures contracts has the following consequences:

1. The expected return of the futures contract is only determined by the excess return of the market over the risk-free rate and beta. Hence the intercept/alpha of the empirical CAPM model must be zero indicating the absence of any other risk factors.
2. If the futures contract is not sensitive to the excess return of the market over the risk-free rate and hence has zero beta, then its expected return must be zero.

Three-factor model

We add two additional risk factors in order to explain the expected returns on the Fish Pool market. This is inspired by the classical Fama and French Three-Factor Model, which is an extension of the CAPM including the two additional risk factors size and book-to-market value. This model has been very successfully applied to equity, see Fama and French (1992a). In the context of commodity futures contracts however, the inclusion of size and book-to-market value makes little sense, so we propose two alternative factors.

The proposed factors are the weekly returns of share prices for two major companies in the salmon farming business: MOWI (formerly Marin Harvest ASA) and the Scottish Salmon Company (SSC). MOWI is the largest salmon farming company in the world, responsible for close to one fifth of the total world production and hence its share price is a good proxy for exposed equity. The inclusion of SSC provides an international dimension.

The choice of the proposed factors is also intuitive in the sense that one would expect changes in the fundamentals of these two companies not only to be reflected in the returns of the corresponding share prices, but also in expectations about future production and demand and hence in the futures prices. Our empirical model applied to futures is

$$r_{it} = \alpha_i + \beta_i \left(r_{mt} - r_{ft}\right) + \gamma_i\left(r_{mowi}\right) + \delta_i\left(r_{ssc}\right) + \epsilon_{it}. \tag{8}$$

where β_i; r_{mt}; r_{ft} and r_{it} have the same definitions as in the CAPM analysis (Equation (6)); r_{mowi} is the return of MOWI share prices; r_{ssc} is the return of the Scottish Salmon Company share prices and α_i is the unsystematic risk when all three risk factors are zero.

Empirical analysis

Raw data

The data used in the current study include closing prices of futures contracts from Fish Pool ASA (part of Oslo Bors ASA); Oslo Stock Index All Share Index (OSEAX); MOWI and Scottish Salmon Company (SSC) share prices as well as the three-month Norwegian Treasury Bills. The frequency of all observations across the data is weekly (synchronous) from which weekly returns (weakly mean for daily prices) are computed (except for data on interest rates) and are quoted in Norwegian Kroner (NOK) since all the companies involved are Norwegian.

Fish Pool ASA is a Regulated Marketplace for international trading of financial salmon contracts located in Bergen, Norway, and is surveyed by the Financial Supervisory Authority of Norway (Kredittilsynet). The data on the futures contracts (accessed from the Refinitiv data base) is the closing prices of all futures contracts from August 07, 2010 to April 03, 2020. Fish Pool ASA has established its own price index (Fish Pool Index^{TM}) which is the basis for all settlements of financial salmon contracts at Fish Pool. This index is composed of several price elements related to the average weekly spot price of buying and selling of fresh Atlantic salmon and all settlement is on a monthly basis against this index to assure neutral and secure trading for all members. Fish Pool states that all settlement is carried out shortly after the end of each month and thus for the purpose of this study the 30th of each month is assumed as the expiration day (FishPool, 2011). As the Fish Pool markets prices are listed in Euros we had to convert these to Norwegian Kroner in order to be consistent in the estimations. We used the daily close on EURNOK as published by Norges Bank (Norway's central bank).

The difference in time to maturity in the contracts is the basis for the separation of data and due to the monthly settlement of all contracts, the length of different panels is specified in the following way. Three panels of futures contracts are created. The first panel contains 1 month (short term) futures contracts (with time to maturity varying between 0 and 30 days). The second panel contains contracts with maturity 6 months and finally the third panel contains 12 months contracts. We are testing for alphas in futures returns in the same way as this is done for other assets, but with the necessary modifications discussed in Section "Three-factor model." The future's returns can in principle be identified with the returns of a trading strategy which holds one futures contract which is closed out and reentered on a weekly basis. The future's returns reflect the cash flows on the trading account. Our analysis is based on 502 weekly observations.

MOWI is the world's largest producer of farmed salmon with close to one-fifth of the global production, located in Bergen, Norway. The new MOWI was founded in 2006 as a result of a merger between Pan Fish ASA; Fjord Seafood ASA and Marine Harvest N.V. It produces in 6 countries (Norway; Scotland; Canada; Chile; Ireland and Faroe Islands); has worldwide operations in 22 countries; sells to over 50 countries in the world and has 6,200 employees. The data on MOWI weekly share prices, is synchronized with the data on the futures contracts.

The Scottish Salmon Company (SSC) is a Norwegian company based in Scotland which supplies fresh salmon worldwide and produces 20% of Scottish salmon.

The Oslo Stock index All-Share Index is a market capitalization weighted index that tracks the stock performance of all shares listed on the Exchange in its respective sectors. It has 172 members including MOWI and SSC. This index is chosen over the other Norwegian index; OSE Benchmark Index (OSEBI) which has only 64 members and does not include SSC.

Estimation method

We estimated Equations (6) (the CAPM model) and (8) (the three-factor model) using the generalized methods of moments (GMM). GMM, in contrast to OLS, is robust to departures from normality, heteroscedasticity and autocorrelation (e.g., Cochrane, 2005; MacKinlay and Richardson, 1991; Wooldridge, 2001).

The *t*-statistics was computed based on heteroscedastic and autocorrelated consistent (HAC) standard errors, according to Newey and West (1987). Collective significance of the impact of independent variables was tested using the *F*-test.

The hypothesis tests

For the CAPM analysis, a violation of the CAPM is tested by considering the null hypothesis $H_0: \ \alpha_i = 0$ such that the abnormal/excess return of the futures is zero (CAPM holds), against the alternative hypothesis H_1: $\alpha_i \neq 0$ that the abnormal/excess return of the futures is non-zero (CAPM does not hold). Next, the sensitivity of the futures to the market risk or in other words the existence of a risk premium on systematic risk is tested by considering the null hypothesis H_0: $\beta_i = 0$ such that the futures expected return's sensitivity to the excess market return over the risk free rate is zero (zero beta); against the alternative hypothesis H_1: $\beta_i \neq 0$ that the futures return's sensitivity to the excess market return over the risk free rate is non-zero.

For the Three-Factor Model, the hypothesis test for beta as in the CAPM analysis applies to all three factors (beta; gamma and delta) to measure the sensitivity of the futures returns to the excess market return over the risk-free rate, the returns from MOWI and the Scottish Salmon Company. Similarly, the hypothesis test for alpha accounts for unsystematic risk when all three risk factors are zero. Furthermore, the joint effect of the excess market return over the risk free rate and the returns of MOWI and the Scottish Salmon Company on the expected return of the futures is tested by performing the *F*-test such that the null hypothesis, $H_0 : \alpha_i = \beta_i = \gamma_i = \delta_i = 0$ is considered against the alternative hypothesis $H_1 : \ \textit{not all coefficients are simultaneously zero}.$

Testing for structural stability (stability of alpha and beta)

In order to use historical data in the CAPM analysis, the relation between expected returns and excess returns of the market over the risk free rate (beta) is assumed to remain constant over the sample period. Similarly, abnormal returns (alpha) are assumed to stay stable over the sample period.

Table 1. CAPM results.

		1 month contract		6 months contract		12 months contract	
Parameters	Label	Coeff.	HAC SE	Coeff.	HAC SE	Coeff.	HAC SE
Alpha	α	0.515	0.898	0.459	0.581	0.547	0.455
Beta	β	0.380	0.406	−0.023	0.205	0.005	0.157

*** = 0.1% significance level, ** = 1% significance level, * = 5% significance level.

However, empirical studies of the CAPM have shown that beta is not stable and that the CAPM model is not robust to sub-samples (Black et al., 1972). Therefore, it would be of great interest to test the stability of both beta and alpha. To account for this we performed a recursive estimation analysis.

Results of the CAPM analysis

The results of the CAPM analyses are presented in Table 1. Below, the results for each of the 3 contracts are discussed.

For the 1-month contracts, the null hypothesis H_0: $\alpha = 0$ cannot be rejected. This implies that α or excess/abnormal return is statistically not different from zero and there is no violation of the CAPM. Further, the estimated Beta coefficient is not significantly different from zero. This implies that the expected futures return is not sensitive to the excess market return over the risk free rate, ie. exhibits no risk premium.

The results for the 6-months contracts are similar as both the alpha and beta estimates are not statistically different from zero. The results for the 12-months contracts are similar to the 1-month and 6-months contracts, where both the alpha- and beta coefficients are still statistically insignificant.

Figure 1 shows the results of the recursive estimation of the CAPM. The first of the recursive windows contains 52 weeks (i.e., 1 year) and increases by one week at a time. The final points in all graphs within Figure 1 corresponds to the estimated coefficients in Table 1. The results in this figure show that there have been some developments in the market over time. In the early periods of the market, all contracts had negative alphas and the coefficient for the 12-months contracts was also significantly different from zero using data for the first year (52 weeks). In all cases, the alphas have moved toward zero as the market has matured. The beta, on the other hand, have been more stable over time. For all maturities, and for all sizes of the recursive windows, the estimated beta coefficients are not significantly different from zero. The variation in the estimated coefficients is larger for the contracts with the shortest maturity. This makes sense in light of Haugom and Ray (2017) as liquidity increases with the delivery period approaching.

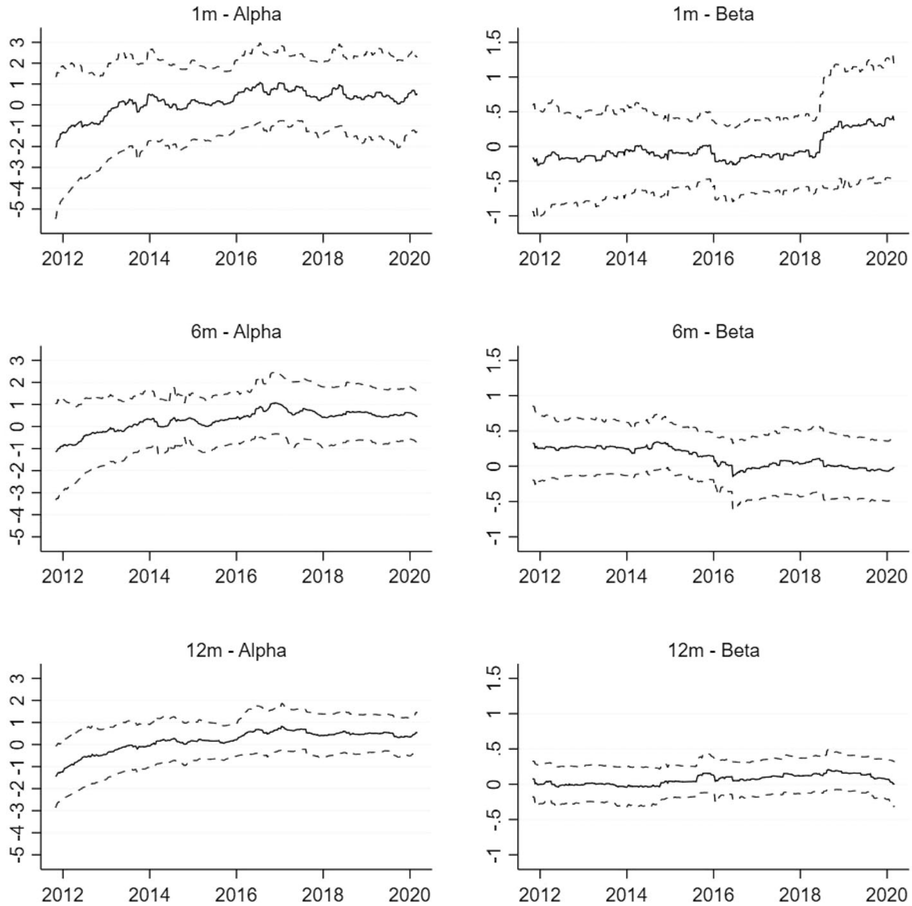

Figure 1. The figure presents results for recursive regressions of the CAPM for the 1-, 6-, and 12-months contracts. The first of the recursive windows contains 52 weeks (i.e., 1 year). The window increases by one week at a time. The confidence bands illustrate ±2 standard errors.

Table 2. Three-factor model results.

		1 month contract		6 months contract		12 months contract	
Parameters	Label	Coeff.	HAC SE	Coeff.	HAC SE	Coeff.	HAC SE
Alpha	α	0.414	0.992	0.255	0.545	0.450	0.419
Beta	β	0.250	0.479	−0.557*	0.226	−0.258	0.182
MOWI	γ	−0.157	0.281	0.472***	0.124	0.251*	0.113
SSC	δ	0.356	0.215	0.270**	0.088	0.113	0.060

*** = 0.1% significance level, ** = 1% significance level, * = 5% significance level.
SSC: Scottish Salmon Company.

Results for three three-factor model analysis

The results for the three-factor model analysis are presented in Table 2 and discussed below.

For 1-month contracts, the null hypothesis for the F-test to examine the joint effect of the independent variables cannot be rejected at the 5%

significance level, implying simultaneous zero coefficients. Furthermore, the results for MOWI and SSC show that all the coefficient are not significantly different from zero.

For the 6-months contracts, the *F*-test of the joint effect of the independent variables cannot be rejected at 1% significance level. The results in Table 2 show that the alpha coefficient is not statistically different from zero, while all three risk factors are statistically significant different from zero. An increase of 1% point in the market risk premium implies a reduction at 0.557 NOK per contract of the 6-months futures. Opposite, an increase of 1% point in the share prices of MOWI and Scottish Salmon increases the 6-months futures contract by 0.47 NOK and 0.27 NOK, respectively. The positive relationship between Fish Pool futures and the two salmon companies is intuitive, as both companies represent producers that benefit from a higher expected spot price. On the other hand, the market portfolio in aggregate is more likely to represent investors and the consumers, so the negative coefficient is not unexpected.

For the 12-months contracts, the *F*-test of the joint effects of the independent variables can also be rejected at 1% significance level. An increase of 1% point in the share price of MOWI increases the 12-months futures contract by 0.25 NOK.

Conclusion

Futures on fresh farmed salmon in the Fish Pool market in Norway are analyzed through the lens of the Capital Asset Pricing Model by adjusting the CAPM so as to accommodate the fact that at initiation futures have a de-facto value of zero. When the futures are sorted by their maturities; the analysis finds that the CAPM applies for all investigated contracts, both alphas and betas are zero. In consequence, salmon futures do not pay a systematic risk premium and should mainly be considered as hedging instruments, not as investment assets. We also observe a process of market maturation from the early years of the Fish Pool market, when estimated alpha's are declining in absolute value, indicating that the market has become more efficient since then. Furthermore, studying the performance of share prices of two major salmon farming companies, MOWI and the Scottish Salmon Company in the context of the Fishpool market; a Fama and French like three factor analysis is adopted. The results obtained through this approach confirm the hypothesis of no excess returns in the Fish Pool futures market but find that the coefficients linked to MOWI and the Scottish Salmon company share prices are mostly statistically significant for the longer contracts.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes

1. When firms deal through their own banking connections, they no longer require an explicit margin. This is typical in forward foreign exchange markets.
2. The margin being a very small fraction of the value of the contract in comparison to the initial investment in the case of stocks where 100% of the price of the stock is invested at purchase suggests that the futures returns should not be calculated in the same way.

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