PAIRS TRADING

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INTRODUCTION

In this assignment we will look at pairs trading. The purpose is to find two companies that are appropriate to use in a pairs trading portfolio and generate a pairs trading strategy. The strategy generated in this report is based on a data set called past. Further, we use the strategy on a data set representing the future in order to analyse how we performed with our pairs trading portfolio and strategy in this assignment.

We wanted to further investigate the possibility of pairs trading within the fish farming industry, and chose Lerøy and Marine Harvest as the companies for our portfolio. The companies where chosen due to the fact that they are the largest players in this industry in Norway.

In this report, we will give a short introduction to pairs trading before we further look into the actual performance of the pairs trading. We will explain how we executed the pairs trading in the project. Further, we will generate a strategy to perform the trading, and analyse how we would have performed with this strategy. Last, we also discuss some aspects of our model.

PAIRS TRADING

Throughout this section we use Harris (2003) chapter 17, page 347-379 as a reference. In order to explain pairs trading, we have to start with arbitrage trading in general. Pairs trading is one form of arbitrage trading. We will focus on how to choose a pairs trading portfolio, why pairs trading works, and what risks are associated with pairs trading.

Arbitrageurs are speculators who trade on information about relative values. They buy instruments that seem relatively cheap and sell those which seem relatively expensive. Arbitrageurs trade instruments whose prices are correlated, this means that the prices tend to rise and fall together. Instruments typically have correlated prices when their values depend on common fundamental factors or when the demands of uninformed traders to buy or sell the instruments are correlated. They profit when prices converge, thus their purchases are relative to their sales.

Arbitrageurs form opinions about the normal relations among correlated instruments. An opportunity for arbitrage arises when the prices of correlated instruments diverge from their normal relations. They then buy those instruments which have become relatively cheap and sell those which have become relatively expensive. If the prices of the instruments return to their normal relations, the prices have converged and the strategy is profitable. They close or unwind their positions when the arbitrage converges. When the prices again diverge after they converge they open the pairs trading portfolio, which also can be called to put on the arbitrage.

The portfolios that arbitrageurs construct are their hedge portfolios. Hedge portfolios usually consist of one or more long positions and one or more short positions in various correlated instruments. They are constructed to minimize the total risk of the portfolio, as hedge portfolios are generally less risky than the positions in the individual instruments. The reduction in risk is due to the offsetting effects of having long and short positions in instruments whose value depend on the same factors. When changes in these factors cause instrument value to fall, the gains in the short position offset losses in the long position. Likewise, when changes in these factors cause instrument values to rise, the gains in the long position offset losses in the short positions.

Pairs trading is one type of speculative arbitrages. Speculative arbitrages involve arbitrage hedge portfolios whose values are nonstationary. This means that an increase or decrease in its current value causes us to expect that all future values of the variable will be higher or lower. Nonstationary variables tend to wander

around without regularly returning to any particular value. The best estimate of a distant value of a nonstationary process always depends critically on the current value of the process. These estimates therefore change through time. Nonstationary variables do not have mean values, long run averages of their value do not converge. Instead, averages of their values also wander about.

Speculative arbitrages involve nonstationary hedge portfolios that arbitrageurs believe have a strong tendency toward short term mean reversion. The nonstationariness is due to instrument-specific valuation factors that cause prices to follow a random walk in the long run. The mean reversion may come from inconsistent pricing of the common factors among the instruments in the hedge portfolio or from mispricing of one or more specific factors.

Pair traders try to identify pairs of investments that they believe are mispriced relative to each other. Further, they buy the stocks that are cheap, and sell the ones that appears expensive. This is profitable when the prices of the two instruments have diverged because their common fundamental valuation factors are not consistently priced, or because traders have mispriced some instrument specific factors. Pairs trading is not profitable when the change in relative prices is due to a change in instrument-specific valuation factor. When specific valuation factors change, the arbitrageurs cannot expect that the basis will converge.

Pairs traders are most successful when they accurately can predict whether changes in a spread will be mean reverting or permanent. They therefore pay close attention to the order flow to determine whether prices are changing in response to traders made by uninformed traders or informed traders. Since pairs traders generally do not know, they often make mistakes. Pairs traders also pay close attention to how quickly and how efficiently markets respond to new information about common fundamental factors. Arbitrageurs generally should be reluctant to trade against markets that efficiently aggregate new information because the prices in such markets tend to accurately reflect fundamental values.

Regardless of that the pairs trader has correctly identified a true arbitrage opportunity, pairs trading is risky. They are exposed to the possibility that some instrument- specific event will cause one or both prices to permanently move against their positions while they wait for convergence. There are several things that can go wrong in pairs trading; Implementation risk, Basis risk, Model risk and cost of carry risk.

Implementation risk is the risk of going long on one leg, but fail to go short on the other before a market wide decline. It is important to build the positions for pairs trading in parallel in order to avoid this issue, as arbitrageurs face this risk

when they establish and close their positions. In this stage, they risk that transaction cost will be grater than expected. Basis risk appears when selling the hedge portfolio and the prices fail to converge. If the arbitrage basis move in the wrong direction, the hedge portfolio decreases in value. If pairs traders are right, the prices will eventually converge, however they might be forced to close the position due to the lack of capital. Therefore it essential with buffer. Model risk is the risk of a changing fair value, this is also know as analytic risk. The fair value can for example change if something important is happening to one company, but not the other. This may be a result of arbitrageurs fail to properly understand the fundamental value relations among the instruments they trade. They then may mistakenly enter an arbitrage on the wrong side. Cost of carry risk is the risk that hedge portfolios will prove to be more costly to carry than arbitrageurs expect. This appears for example when the short leg decides to pay a large dividend. Also, as prices diverge, and demands more margin.

Good and bad events tend to offset each other, and pairs traders do not expect to lose money on average when they fail to identify a profitable arbitrage opportunity. However, they may loose due to the cost of establishing and financing their positions.

EXECUTION

This part of the report describes how the pairs trading is executed. As we are developing a pairs trading strategy and then putting it to use in the report, we describe the approach we used to treat historical data as future values, and further implementing the strategy and analyze the result.

In order to execute this pairs trading, and evaluate the result, we have extracted data in two periods. The first period is considered to be the past, and the second period is considered to be the future. This is done to first develop a strategy based on historical data without knowing how the end positions for the Lerøy and Marine Harvest shares would look like. This information can affect the decisions we make when coming up with a pairs trading strategy. The data we have extracted is the daily share values at the end of each day, these values are also adjusted for dividend. This way, we do not have to consider this further in this report.

The past in this assignment is the period between 28.11.2005 and 31.12.2009, and the share values we use as a basis for developing a pairs strategy was extracted separately from the future data. The future in this assignment is the period between 01.01.2010 and 28.11.2016. This is the period where the strategy is implemented and we trade using the strategy we decided based on the development in the first period. The first day of utilizing the strategy is 01.01.2010. This is also the period we use to calculate our result from the pairs trading. The data collected is processed in Excel, where we have one column for dates, one for the stock prices for Lerøy (Yahoo finance, 2016a) and one for Marine Harvest (Yahoo finance, 2016b).

In the excel sheet, we have calculated the relative fair value of each company separately. This is done by dividing the share value of each company on the value it had the first day in the data set for the past. We have used these values to calculated the fair value by dividing the relative fair value of Lerøy with the relative fair value of Marine Harvest. To calculate the profit and loss, we also have one column that state the position in the portfolio where the portfolio has taken a long position if it is 1, closed for 0 and short for -1. The total profit and loss is calculated by summarizing the profit and loss for each share. In this report, we have also looked at the correlation between each company, and generated a column that calculates the development in correlation over time.

SELECTION OF PORTFOLIO

When selecting a portfolio for pairs trading, it is important to choose highly correlated shares. It is assumed that shares within the same industry correlates,

as they are affected by the same factors. For this assignment, we decided to look at the fish farming industry. We chose the two different shares Lerøy and Marine Harvest, as they are the largest companies within this segment in Norway.

LERØY

Lerøy was listed at the Oslo stock exchange for the first time in June 2002. Today, they are the second largest producer of Atlantic Salmon and a leading exporter of Norwegian seafood. Lerøy's core activities are distribution, sale and marketing of seafood, processing of seafood and production of seafood and product development. They have fourteen processing facilities all over Europe. As they are following each step in the production from salmon egg to the finished product, Lerøy is wholly integrated company (Lerøy, 2016a). Calculated with the present number of shares (54 577 368) and the stock value 25.11.2016 (460,30 NOK), Lerøy's market value is estimated to be 25,1 BNOK (Lerøy, 2016b)

MARINE HARVEST

Marine Harvest is one of the largest seafood companies in the world, and the largest producers of Atlantic Salmon in the world. They operate the entire value chain of all its products (Marine Harvest, 2016a). They are represented in 24 countries, and is listed at both the Oslo Stock Exchange and at the New York Stock Exchange. Calculated with the present number of shares (450 207 148) and the stock value 25.11.2016 (154 NOK), Marine Harvest's market value is estimated to be 69,3 BNOK (Marine Harvest, 2016b).

CORRELATION

Correlation is a measure on how two securities move in relation to one another. The correlation is calculated into a correlation coefficient which has a value between 1 and -1. A correlation coefficient equal to 1 means that the two securities are perfectly correlated. In other words, in case of a movement in one of the securities, the other security moves in lockstep (the same movement). A correlation coefficient equal to -1 means that the two securities have a perfectly negative correlation. In case of a movement in one of the securities, the other security move in lockstep in the opposite direction. If the correlation coefficient is equal to zero it means that the two assets have no relationship (Investopedia, 2016a).



Figure 1: Stock price development for Lerøy and Marine Harvest

Figure 1 illustrate the development in the price of Lerøy and Marine Harvest. These values have been used to calculate the correlation between the two shares in Excel. Figure 2 illustrates the development in correlation over time.

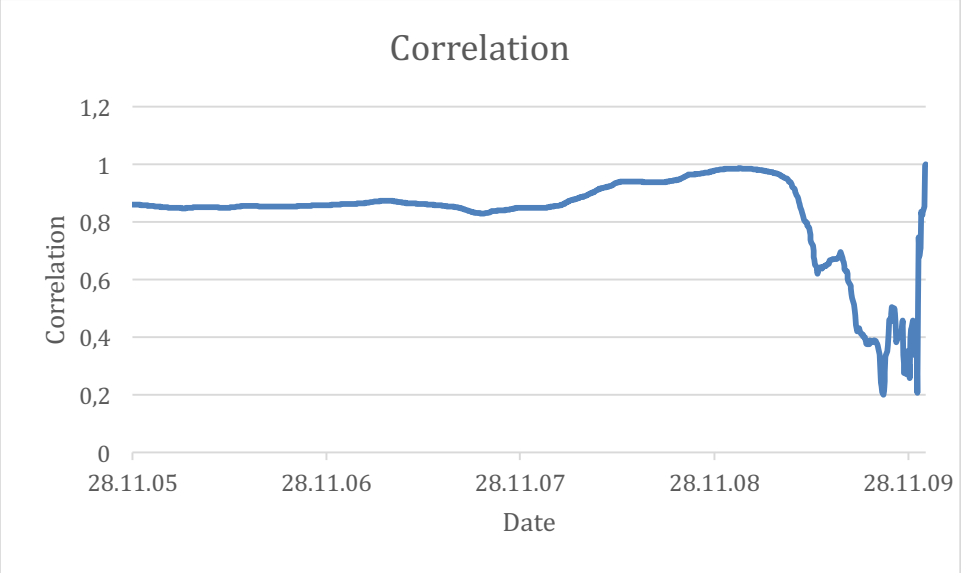


Figure 2: Correlation, past period

The development in correlations shows that in the beginning of the historic data the correlation was stable between 0,8 and 1. The correlation is stable in this interval until 2009 when it becomes volatile, and continues with the volatile behaviour towards the end of the period. At the very end of the past data the correlation returns to a value between 0,8 and 1. With a correlation coefficient between 0,8 and 1 for the most part, the relationship between the two shares is strong.

The correlation coefficient of the whole period of the past data is 0,862. The coefficient can be interpreted as the amount of time the where there is a perfect positive correlation between the Lerøy and Marine Harvest. Thus, during the period of the past data there is a perfectly correlation between the shares 86,2 percent of the time. The strong correlation coefficient tells us that two companies are good candidates for pairs trading.

FINDING A STRATEGY

In order to decide on a strategy for pairs trading on the two shares, it is necessary to look at development in relative fair value. Relative fair value is the benchmark value between the shares and we use it to evaluate the relationship between the shares. We assume that the relative fair value is the ratio in the prices on the first date in the collected data. Thus, we have a relative fair value of 41,17:18,63. By dividing the price for the Lerøy share on 41,17 and the price for the Marine Harvest on 18,63 we scale the units to get a relative fair value of 1:1. By plotting the relationship between Lerøy and Marine Harvest in a graph is it possible to study the development in fair value during the period of the historic data. The development in fair value is illustrated in figure 3.

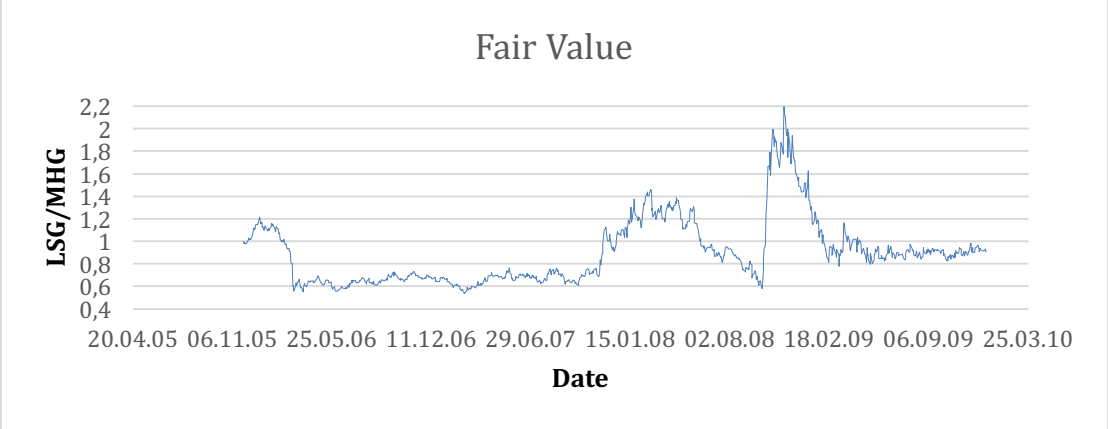


Figure 3: Fair value, past period

The aim of pairs trading is to earn a profit when the fair value between the two shares diverge with the presumption that the shares will converge again. The further from a fair value of 1, the more the share price diverge. When the fair value move towards 1 again, the prices converge.

We have set up the portfolio of buying Marine Harvest (MGH) and selling Lerøy (LSG) (Portfolio: LSG-MHG). Figure 3 shows that the two shares diverge at several occasions and there are therefore opportunities to earn a profit.

Pairs trading is, as stated, possible when the shares are mispriced relative to each other. Pairs traders should buy the ones that appears cheap, and sell the ones that appears expensive. In this case, Marine Harvest appears cheap when the fair value of LSG/MHG is over 1 and appears expensive when the fair value of LSG/MHG. For Lerøy, it is opposite. The Lerøy share appears cheap when the fair value is less than 1 and expensive when it is over. Therefore, the portfolio should

take a long position when it is less than 1 and a short position when it is larger than 1.

Based on the development in fair value we have decided on a strategy of buying the portfolio when the fair value falls to 0,8 and selling the portfolio when the fair value rises to 1,2. When the two shares converge so that the fair value reaches 1, we will close the position. To consider small changes that can happen internally in each company, we do want to open the portfolio before there are some divergence. We have set the limit to 20 percent divergence before any action is taken in the portfolio. Since we have developed the pairs trading strategy on the development in the historical data, we find it interesting to test the strategy on this period before we decide on whether to apply the strategy in the future.

Figure 4 illustrates when action would have been taken if we had opened a pairs trading portfolio with Lerøy and Marine Harvest in 2005. We would have taken a short position three times, illustrated by the red circles. The position would have been closed four times, illustrated by the orange circles. Last, we would have taken a short position three times, illustrated by the green circles.

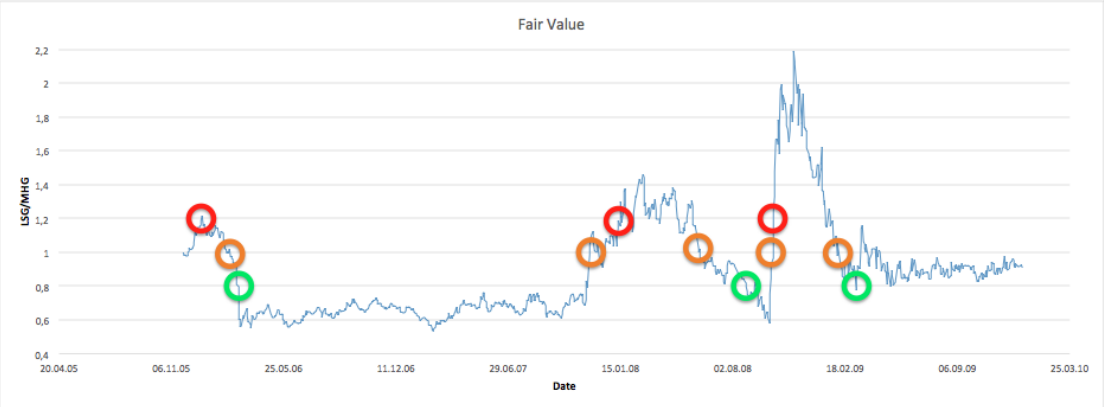


Figure 4: Actions, past period

The actions in the pairs trading portfolio are also be presented in table 1, where the date for each action is specified.

Table 1: Actions, past period

Date	**Action**
30.12.05	Take short position
13.02.06	Close down position
06.03.06	Take long position
22.11.07	Close down position
15.01.08	Take short position
05.06.08	Close down position

26.08.08	Take long position
14.10.08	Take short position
04.02.09	Close down positions
10.03.09	Take long position
18.03.09	Close down position
11.05.09	Take long position

Except for the dates in table 1, no further actions are taken in the portfolio. This means that over the period of a little over four years, there would have been taken 12 actions in running this portfolio.

The profit and loss of the pairs trading portfolio is illustrated in figure 5 below.

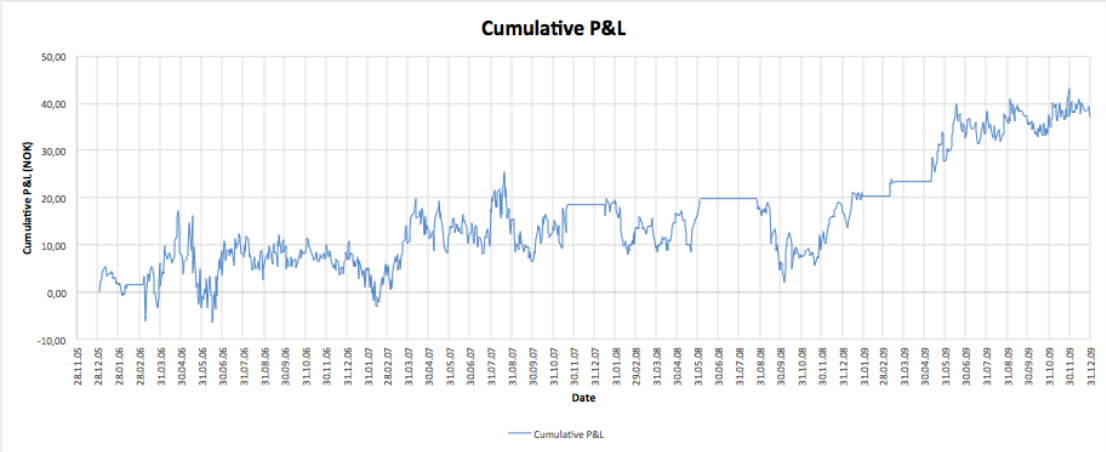


Figure 5: Cumulative profit and loss, past period

Figure 5 illustrates that there are some fluctuations in the profit development from the portfolio in the beginning, but overall there is a steady profit increase. However, in some periods, the portfolio also loose money. The cumulative profit and loss curve, can also be compared to the development in the share price for Lerøy and Marine Harvest. This is illustrated in figure 6.

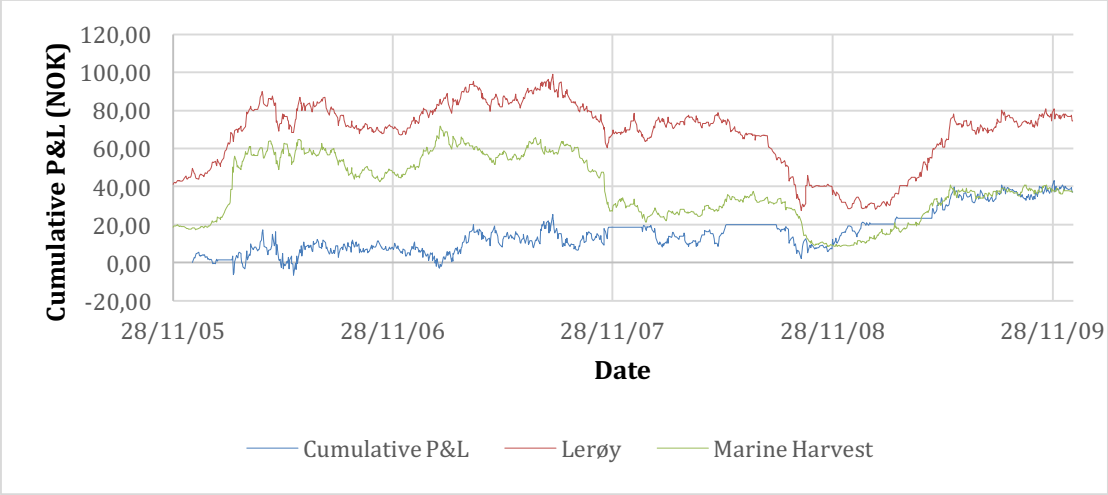


Figure 6: Results, past period

The portfolio fail to exclude the sudden fall in prices for both Lerøy and Marine Harvest in 2005. However, the drop in prices for both Lerøy and Marine Harvest in the beginning of 2008 is avoided to some degree. Towards the end of the period the portfolio outperforms the Marine Harvest share.

Table 2 below show the annual rate of return, where return in 2005 is calculated from 25.11. This demonstrates that the strategy is profitable.

Table 2: Annual return

Annual return	Start	End	Return
2005	0	0,00	0 %
2006	2,71	8,49	213 %
2007	7,09	18,59	162 %
2008	18,59	16,75	-10 %
2009	16,75	37,06	121 %
Average			122 %

Based on our finding in developing the strategy, we see that the strategy would have been profitable in the period between 2005 and 2009 with an average increase of 24% (122 %/5 years). Thus, we will open a pairs trading portfolio with Lerøy and Marine Harvest from the first of January 2010 using the developed strategy.

ANALYSIS

As we have developed and tested the pairs trading strategy, we now implement the strategy on the future data. This is the real test of our strategy as we have not seen how the two companies develops in this period, and our strategy is therefore not influenced by the future development. We have plotted the fair value over the duration of the future period in figure 7, and figure 8 shows when we take actions in the portfolio using the strategy.

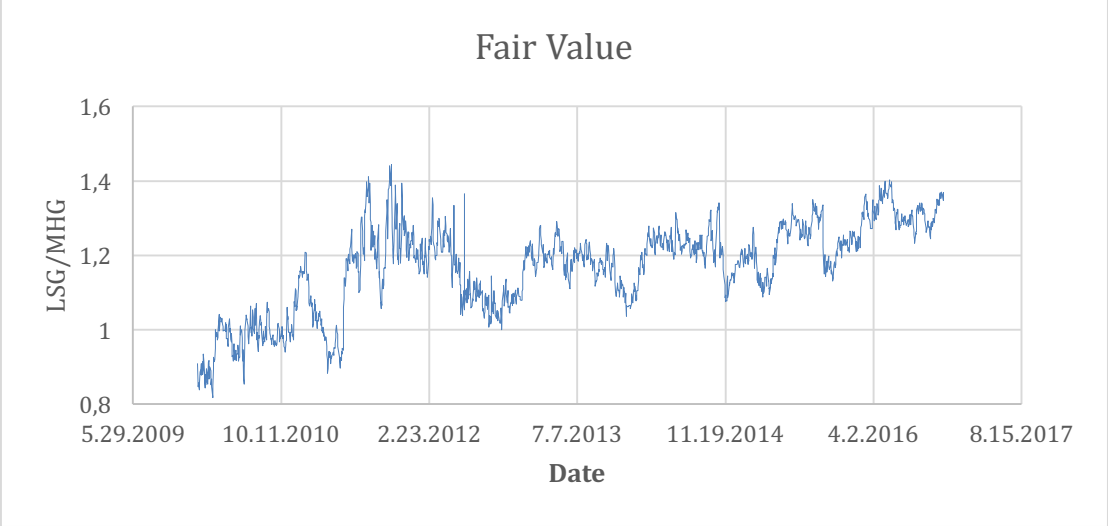


Figure 7: Fair value, future period

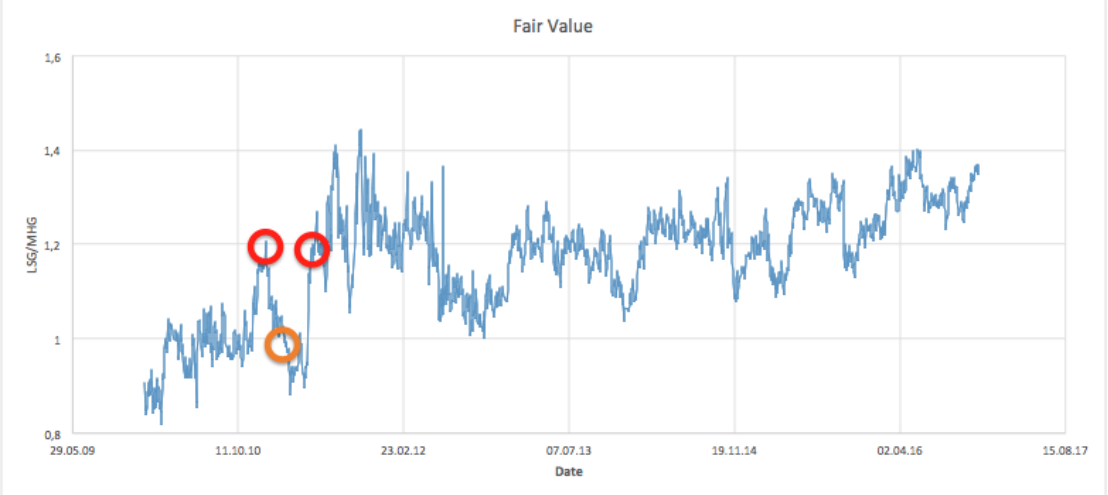


Figure 8: Actions, future period

The development in fair value show that in the beginning of the period the fair value is relatively stable around 1. We do not trade on the portfolio before the fair value rises to 1,2, indicated by the first red circle where we take a short position. Not long after the fair value falls to 1 and we close the position,

indicated by the orange circle. The fair value then rises to 1,2 and stays above 1 throughout the period. We therefore take a short position at this time and keep this position for the rest of the period.

Table 3, specifies the date of action in the portfolio.

Table 3: Actions, future period

Date	Action
30.12.2010	Take short position
25.02.2011	Close Position
26.05.2011	Take short position

With this development in fair value we have only acted on our position three times during the future period. Since the fair value does not converge back to 1 the strategy fails to earn any profit, as the strategy is depending on that the fair value will converge again. Figure 9 illustrate the development in the cumulative loss as a result of our chosen strategy.

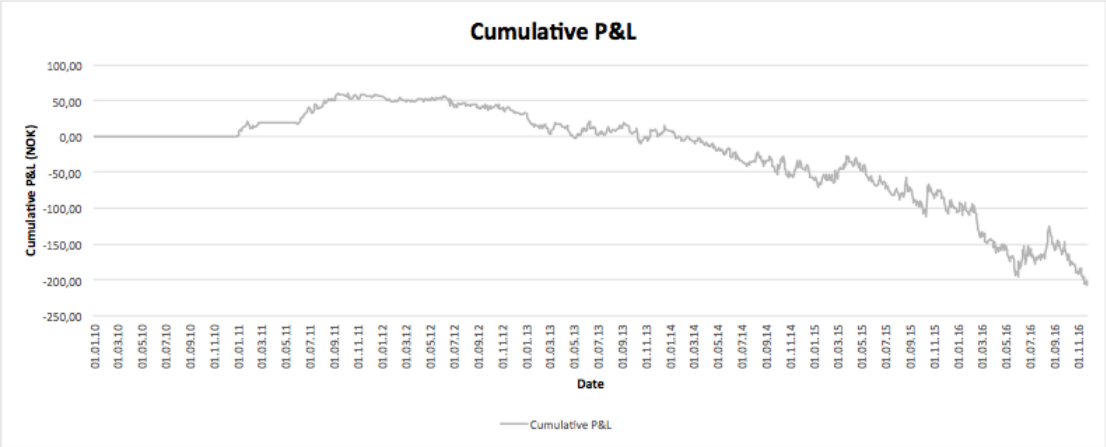


Figure 9: Cumulative profit and loss, future period

The results from the pairs trading strategy can also be compared with the price development in the two shares, illustrated in figure 10. Figure 10 shows that the trading strategy fails, resulting in a large cumulative loss while the value of both shares increase.

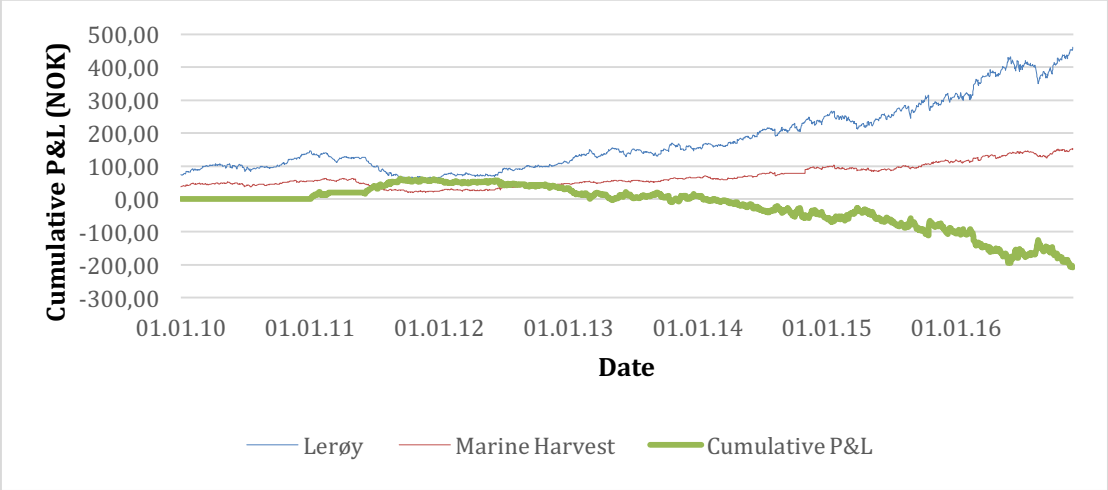


Figure 10: Results, future period

The table 4 below illustrates the annual return with our chosen strategy.

Table 4: Annual return, future period

Annual return	Start	End	Return
2010	0,00	0,00	0 %
2011	0,70	54,85	7679 %
2012	56,06	33,69	-40 %
2013	33,69	7,49	-78 %
2014	-15,21	-59,20	-289 %
2015	-59,20	-105,09	-78 %

In order to find out why our strategy failed to earn a profit we must look at the correlation between the two shares during the future period.

Based on the development in prices for each company we have calculated the correlation between them during the future period. Figure 11 shows the correlation over time. The correlation is stable and close to 1 from the beginning of the period until the beginning of 2016. In the beginning of 2016 the correlation is volatile and drops to 0,4 at one point, before it rises back to a value between 0,8 and 1. The total correlation coefficient is calculated to 0,9904 and can be interpreted as that the shares are perfectly positively correlated 99 percent of the time. Thus, the correlation between the shares are even stronger in the future period than in the past period.

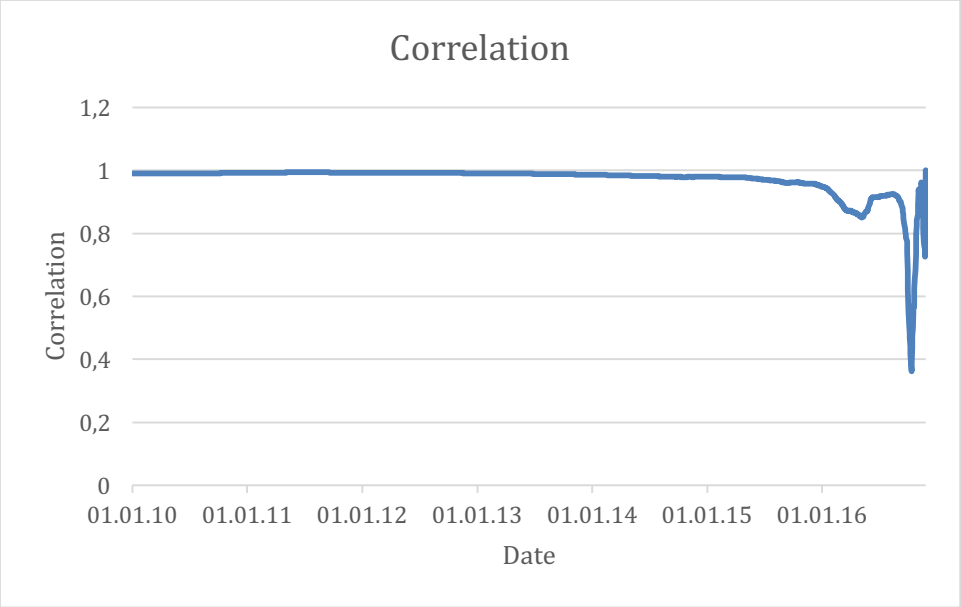


Figure 11: Correlation, future period

Since the correlation is even stronger in the future period it must be other factors that cause the strategy to fail. By looking at the development in the share prices in figure 12 we see that the from around January 2013 the Lerøy share increases more rapidly than the Marine Harvest share.

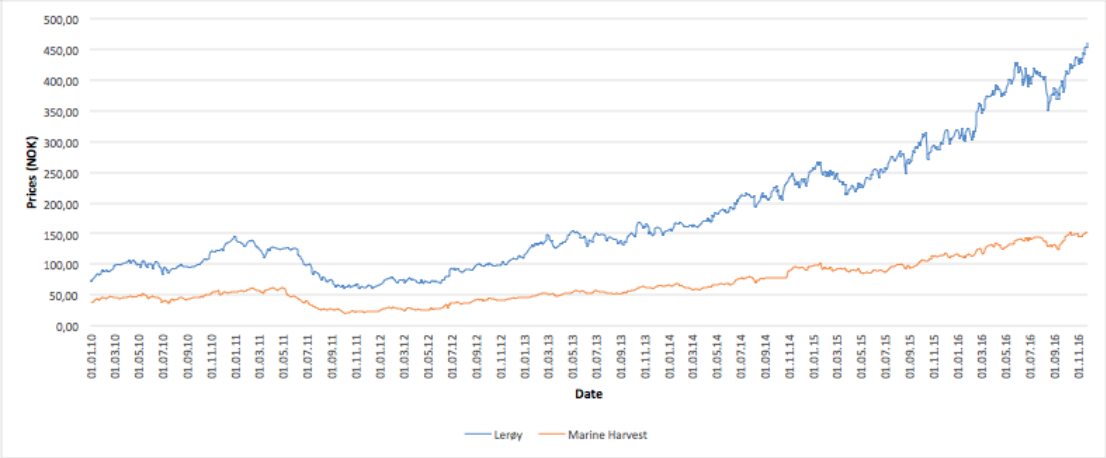


Figure 12: Price development, future

This development continues throughout the period. This increase in Lerøy, without Marine Harvest following to the same extent, results in that the fair value fails to converge to 1. This is one of the four mentioned risks that can happen with pairs trading. One reason for the failure to converge can be that the fair value has changed, due to an event that affect one of the companies but not the other. If there are no event however, it is possible that the prices again will converge. As part of a strategy, there should be included a protocol for what to do if this would happen.

The failure to converge due to a change in fair value is referred to as model risk. In order to evaluate whether an event has caused the behaviour of one share and not the other it is necessary to look at the actions of both companies at the time when the change in behaviour started.

In 2013 Lerøy took several strategic steps to improve their market position. These steps include acquisition of another fish farming company, establishing a new facility for smolt production and investing in fishcut localities (Lerøy, 2013). During the recent years Lerøy has moved several production areas from Norway to low-cost countries to reduce production costs (Lerøy, 2016c). These strategic actions are likely the reason for Lerøy's increase in share price over the recent years.

During the recent years, Marine Harvest has transformed from being a production-driven fish farming company to an integrated marine protein producer by expanding into into fish feed and broadening their secondary processing operations. To follow up on this strategy they acquired Morpol in 2013. Morpol was a world leading secondary processor of salmon with processing facilities in Poland, United Kingdom and Vietnam (Marine Harvest, 2013).

By looking at the two companies' development over the last 4-5 years both companies have taken strategic steps to ensure their growth in the fish farming industry. Both companies have acquired other fish farming companies to ensure localities in Norway. A difference in their strategy is that Marine Harvest has acquired many small fish farming companies, while Lerøy has acquired fewer, but much larger fish farming companies (Fossan, 2016). These differences in strategy can be reasons for the change in the fair value between the two shares.

The change in fair value causes our pairs trading strategy fail and thus we end with a large loss, as illustrated in figure 9. If this was a real situation, then we as traders should follow the events surrounding both companies and evaluate the effect of these events on the relationship between them. In this situation, we should have seen the development around 2013 and decided on whether to change the strategy, close our position and be content with our loss, or to continue with our strategy with the presumption that the relationship between the two companies will find back to the fair value. The latter alternative entails large financial risk as the loss increases over time, and a lack of capital would eventually force us to close the position.

If we were to choose the opposite strategy, thus taken the opposite position in each action, we would have had a positive profit at the end of the future period.

However, this means that we would loose money in the beginning of the period. This strategy would also contradict the findings when we found in the strategy using the past period. The results indicate that there should have been a switch in the portfolio at some point in the future data set, going from Lerøy - Marine Harvest, to Marine Harvest - Lerøy. This may be a consequence of a change in the fair value of the companies. During the trading period, we as arbitrageurs could have monitored the fair values, and when the fair values appeared to have changed, we should have changed our strategy.

DISCUSSION

The model and strategy developed in this report include several weaknesses that affects the reliability of the results. The different features that constitutes weaknesses with our model are elaborated in the following paragraphs.

Our model does not include transaction costs when making trades. Transaction costs are expenses related to buying and selling shares, and are the payments banks and brokers receive for their roles in the trade. These costs are important to traders as they are important determinants of the net return (Investopedia, 2016b). By eliminating transaction costs, the cumulative profit and loss of the pairs trading are not as reliable. In order to make a judgement on whether the strategy is successful it should include these costs. However, as the pairs trading strategy entails fewer trades in comparison with other more high intensity trading strategies, the transaction costs does not have such a strong impact on the results. Since the aim of the term paper is to learn to implement a pairs trading strategy and analyze the results, it is considered reasonable to not include the effect of the transaction costs.

When establishing the strategy for the pairs trading we settled the fair value based on the initial prices in the past period. Since the relationship between the prices fluctuates it would have been a better approach to look at the mean relationship over the entire past period before setting a relative fair value. By using a relative fair value that is based on the entire period, the fair value would be a better representation of the relationship between the shares over the duration of the past period. It would have been interesting to calculate the mean relative fair value and compare it with the results of the pairs trading strategy with the initial fair value. The decision to use the initial prices as relative fair value was made in order to simplify the process of setting up the strategy. The implementation of the trading method and learning outcome were not influenced by this, and the simplification is therefore considered to be a reasonable approach.

The companies used for the pairs trading have many similarities and are therefore good candidates for pairs trading. However, there are many areas where the two companies are different, causing the two companies to be sensitive to different fundamental factors. While Marine Harvest only produces salmon, Lerøy produces additional products such as Cod, Trout, Halibut among others (Lerøy, 2016d). An important factor for fish farming companies are the general prices for the different types of fish. The main price factor for both companies are the price for salmon, but Lerøy is also sensitive for the general prices for their additional products. Both companies have several production

facilities abroad and Marine Harvest also has fish farms in several locations abroad. Lerøy on the other hand only has fish farms in Scotland in addition to its' fish farms in Norway. The companies are highly sensitive to changes in the surrounding environment for the fish farms. With establishments in different countries there are high chances for that there will occur incidents that will have a significant impact one company, and not the other. These differences in product portfolio and localities makes the two companies sensitive for different fundamental factors. Since the two companies are affected by different factors in their environment it can consequently affect the relationship between them and therefore constitutes a weakness with the model as the strategy is sensitive to several factors.

Another factor that constitutes a weakness with the model is the difference in shareholders of the two companies. Marine Harvest has mostly international investors that own large shares of the company, with John Fredriksen as the majority owner. Lerøy has mostly Norwegian shareholders, and the number of shareholders are higher with smaller shares (Fossan, 2016). The ownership model of each company constitutes a difference in the volatility of their share price. Due to the larger amount of small shareholders the Lerøy share is more sensitive to changes and consequently might make the share price more volatile.

SUMMARY AND CONCLUSION

In this term paper we have found a pairs trading strategy, and applied it to a data set that represents the future in our report. The companies represented in our pairs trading portfolio are Lerøy and Marine Harvest. They are the two largest producers of Atlantic Salmon in the world. Due to this, it is assumed that they are affected by the same factors, and that the prices correlates. This is essential in a pairs trading portfolio.

Our pairs trading strategy failed, and in the end of the trading period, the cumulative loss in our portfolio were around 200 NOK. This happened, even though the prices had a high correlation rate. The strategy failed due to the fact that the prices of the Lerøy and the Marine Harvest never returns to a fair value of 1. Both basis risk and model risk can cause this. After 2013, both companies have taken measures in order to grow in the fish farming industry. The actions taken can have had different effects in each company, and the relationship could be changed, causing the fair value to change.

We also discuss some weakness to our model. We do not include transaction cost and the cost of performing a transaction will affect the result. The fair value is also a factor of weakness in or model, as we calculate the fair value from the first day of collected data. This could have been improved by basing the fair value on a mean value. Another factor is that even though the companies operate in the same industry, they have different products in their portfolios, and different locations all over the world. With different product portfolios and fish farm locations, the two companies are sensitive to different fundamental factors and this can consequently affect the relationship between the two shares. Last, a difference in ownership model of each company might constitute a difference in the volatility of the share price in the two companies.

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