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- TITLE: **Can technical trading strategies in the European natural gas market outperform a buy and hold strategy?**

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Foreword

We would like to give our sincere gratitude for all the help and assistance from our supervisor Bård Misund, as well as the continuously assistance, advice, and dialogue from Westgass AS.

Abstract

Technical analysis is the study of past market history to determine future direction and is a common tool for investors to include in a strategy when trading stocks, futures, and other financial assets. Studies have shown that some technical trading strategies are able to outperform a buy and hold strategy on various financial assets like stocks and foreign exchange futures, but no studies have been done regarding technical trading strategies in the European gas market. Trading of natural gas in Europe has been liberalized in the past 10 years or so, and the volume of futures and forward contracts have increased dramatically, making it possible to efficiently buy and sell these contracts in a liquid market. It might be because the European natural gas market has changed in later years, that there are not any significant research available that have studied the viability of technical trading strategies, and so our paper provides valuable information about their performance in the European natural gas market. Through this paper we have backtested several different moving average crossover strategies, and analyzed their returns, risk, and overall performance, before comparing these results to that of a buy and hold strategy, to find out how these strategies perform. We have tested a total of 80 different moving average crossover strategies, in three different natural gas hubs, providing 240 sets of results. Out of the 240 results, 41,25% had a higher return than a buy and hold strategy, 60% had lower risk, and 42,92% provided a better Sharpe ratio. These results show that a significant amount of moving average crossover strategies provide excess return and lower risk than a buy and hold strategy, and so technical trading strategies in the European natural gas market are certainly worth looking into.

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Introduction

In this master thesis we will analyze the performance of technical trading strategies in the European natural gas market. We will do this by testing several technical trading strategies that can be automated, to see how they perform in the gas market and check how they compare to a buy and hold strategy. If some of the strategies we test manage to outperform the buy and hold strategies, there might be incentive to use them. To measure the results of the strategies, we analyze the returns, risk, and a performance measure of the strategies, which we compare to those of a buy and hold strategy. We are writing on behalf of a firm called Westgass AS which is an independent energy merchant situated in Stavanger, Norway. They want to research more into trading gas and find out if technical trading strategies can be profitable for them or not in the gas market, and so we have taken it upon us to explore this with them and test different strategies on the price data for gas we have available.

The European natural gas market has seen a liberalization in later years, which has opened up the market for more active trading in with futures, and therefore, making it easier to implement trading strategies to make profit of price movements. Through backtesting several different technical trading strategies and comparing the results with benchmarks on the different hubs, we will see how these strategies perform, and if they can outperform a buy and hold strategy. Both for Westgass, but also for other companies that might be interested in automated technical trading strategies in the European natural gas market.

In this thesis our results show that several of the trading strategies manage to outperform the benchmark, and this confirms that the European natural gas market is indeed a market where technical trading strategies can be worth utilizing.

Introduction to natural gas and its financial markets

Natural gas is a natural occurring hydrocarbon that is used as an energy source. It can be used for heating, cooking, to generate electricity, and as fuel for vehicles amongst other things, and so, gas is an important commodity with a significant demand. In this chapter we will investigate the short-term (up to 5 years) supply and demand of the commodity, as well as the evolution of its financial markets.

The supply of gas in Europe is dominated by four major suppliers. Russia being the largest one; In 2017, Russia accounted for 40.32% of gas imports to the EU. Norway was the second largest supplier at 27.28%, Netherlands was the 3rd largest at 10.18% and Algerie was the 4th at 7.91%. Together in 2017, these four countries supplied 85.69% of the gas to Europe. Liquified natural gas stood for 11,61% of the gas supply and then the remaining 3% are some small other suppliers. (McKinsey & Company, 2019)

We will now take a closer look at the short-term demand and supply in Europe(Next 5 years). Looking more closely at the four major suppliers, **Russia** is set to increase their supply to Europe with a new gas pipeline called NordStream 2. There is already a gaspipe called NordStream that runs from Russia to Eastern Germany, and the building of NordStream 2 will increase supply capacity. It will be ready for use before late 2019, and so Russia should be able to increase their supply in the short term. (Gazprom, s.a)

The gas production in **Norway** has increased by about 11,7% from 2014 to 2018.

Gas production in Norway:

Previous:

2014	2015	2016	2017	2018
106,8	114,9	114,5	121,9	119,3

Table 1: Historic gas production in Norway

Forecasted:

2019	2020	2021	2022	2023
119,5	120,2	121,2	121,4	120,6

Table 2: Forecasted gas production in Norway

Norsk Petroleum (Norsk Petroleum, 2019, March 26th) has done a forecast and expect the production for gas to remain mostly steady with a slight positive growth.

Netherlands has since they discovered the big Groningen gas field in 1959 been a key supplier of gas to Europe. However, since a Dutch village was hit by an earthquake in 2012 and people started researching the Groningen gas field, the production has been cut continuously. By 2030, the Dutch government has a target to reach zero production from the Groningen gas field, and so from Netherlands the production outlook is set to decrease.

For **Algerie,** oil and gas production are a very significant part of their economy. 97% of their exports are oil and gas, 2/3rd of their government income comes from these commodities, and so does 1/3rd of their GDP. (OECD, 2003) They are planning to launch a new gas pipeline which will be operational by 2020 which will boost their output capacity, and they are generally looking to boost these commodity outputs as it is big parts of their economy. Their gas exports have continued to rise over the recent years, and it looks like it will continue to do so. And so, it looks like Algeria's gas supply is set to increase. (Montelnews, 2018, October 30th)

Looking at the major suppliers; with Russia looking to increase their supply significantly, Norway staying steady and maybe increasing their supply slightly, Netherlands having a goal to decrease and Algerie looking to increase their supply, in general it seems like gas supply to Europe will increase in the close future.

When it comes to the demand of gas in Europe, the financial crisis hit it significantly. In 2008 the demand for gas was 586 Bcm and it fell to just over 528 Bcm in 2013 (The Oxford Institute for energy studies, 2014, June, p. 71) much due to lower cost coal, and falling electricity demand. Since 2014, the demand for gas in the European Union has had a steady increase of 4-7% yearly (International Energy Agency, 2018, November 13th, p. 200) However, with the rise of environmental-friendly energy sources, the demand of gas in Europe might face stiff competition looking forward.

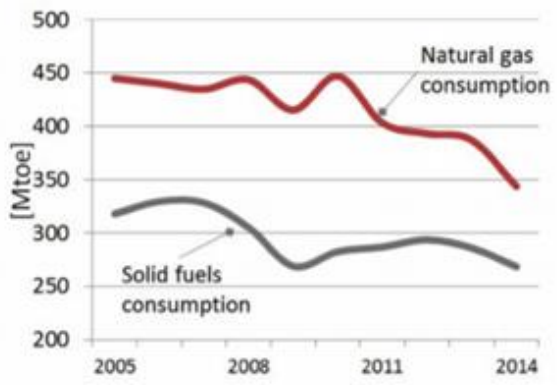

FIGURE 2 – DECLINE OF NATURAL GAS AND SOLID FUELS (COAL) CONSUMPTION BETWEEN 2005 AND 2014 IN THE EU-28 MARKET. SOURCE: EUROSTAT, CIEP©.

Figure 1: Natural gas consumption 2005-2014 (CIEP, 2016, September)

We can see from figure 1 that between 2010 and 2014 the natural gas consumption sank by about a quarter. The EU decarbonization framework has been the main driver behind the big changes of consumption and demand in Europe, because of three big changes:

- Their promotion of renewable energy systems
- The wish to reduce greenhouse gas, greenhouse gas comes from burning fossil fuels such as natural gas and coal, this is to help prevent global warming.
- And energy efficiency improvements.

Different publications have been done trying to forecast the future demand for gas, but there is big uncertainty as we can see below. It depends how much the policies will be pursued in the future, technological innovation, and what energy sources that will be more focused on in the future. In the figure below we see several different forecasts for the demand for natural gas in the near future, and they give very different results, showing the uncertainty of future demand.

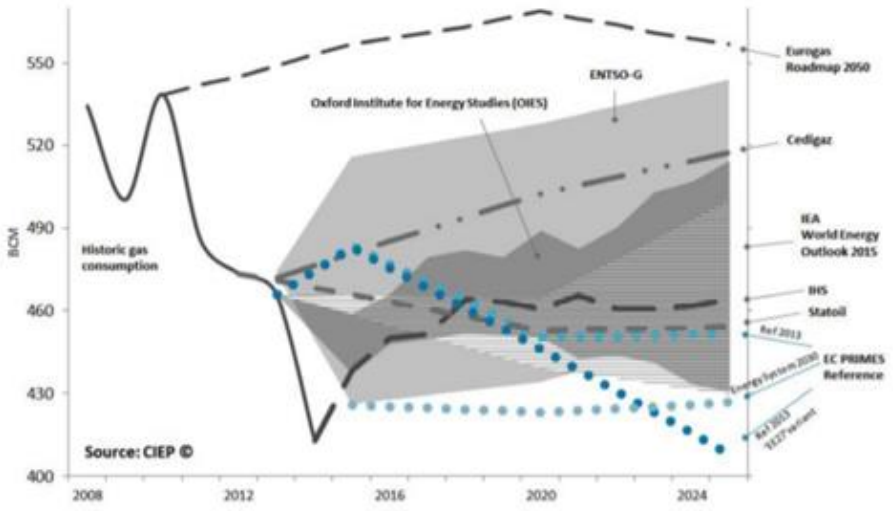

FIGURE 4 – COMPETING PROJECTIONS FOR EU-28 NATURAL GAS DEMAND[33,34]. SOURCE: CIEP©.

Figure 2: Forecast for future demand of natural gas in EU (CIEP, 2016, September)

One of the forecasts in the figure above is the Oxford Institute for Energy Studies. In their forecast they expect the demand in the European region to fall from 594 Bcm in 2010 to 564 Bcm in 2020, and up to 618 Bcm in 2030. This is a pessimistic forecast showing low growth but it is also far from the most pessimistic forecast projected. To summarize, the future demand for natural gas is very uncertain, but a large increase in demand in the short-term seems unrealistic according to forecasts.

Natural gas trading generally occurs in gas hubs located across Europe. The gas hubs with largest trading volume are TTF from the Netherlands, NBP from the UK, and NCG from Germany as a distant third. In 2016 TTF traded for a total of 22230 TWh, NBP traded for 20045 TWh, while NCG traded only for 2080 TWh. Behind these gas hubs, the trading volume gets much lower.

Table 3: Total Traded volumes: 2008-2016

HUB	TOTAL TRADED VOLUMES* (TWh)						
	2008	2011	2014	Δ% =>	2015	Δ% =>	2016
TTF	560	6295	13555	+26	17080	+30	22230
NBP	10620	18000	20505	+2	20955	-4	20045
NCG	360	880	1750	+2	1790	+16	2080
GPL		310	1000	-5	950	+17	1110
PSV	160	185	525	+37	720	+23	885
ZEE+ZTP	500	870	850	-5	805	-3	780
PEG Nord	185	430	435	+15	500	+10	550
CEGH/VTP	165	170	400	-15	340	+56	530
VOB	n/a	n/a	35	+129	80	+31	105
PEG TRS	n/a	SUD 40	80	TRS -27	65	+54	100
		TIGF 5	5				
PVB	n/a	n/a	n/a	-	<10	+200	30

*rounded to nearest 5TWh; not the same data sources in all years.

Sources: 2008: converted from bcm in IEA 2009 Natural Gas Review, p.30;
2011: LEBA, ICIS, ICE, ICE-Endex, EEX, Powernext, CEGH, GME; P. Heather.
2015, 2016: LEBA, ICIS, ICE, ICE-Endex, PEGAS, CME, CEGH, GME; MIBGAS; P. Heather

Table 3: Trading volume in European natural gas hubs (The Oxford Institute for energy studies, (2017, May), p. 4)

From the table above, it is clear how the gas hubs have become much more used in the past few years, where NBP has been an established trading hub for a long time but have still doubled its volume from 2008-2016. TTF have emerged during this time as a main gas hub, becoming the most traded gas hub in 2016, while it only traded for 560 TWh in 2008.

In later years, there have been a liberalization of the European natural gas markets. With the emergence of different gas hubs across the continent, the market has become more open and allowed more nations, especially eastern European nations, to purchase natural gas at prices determined by supply and demand. The gas hubs provide open competition for natural gas and allows countries and industries to choose their supplier themselves. Because of this, markets have become more liquid, and prices are now determined by supply and demand in large parts of Europe. With the natural gas market becoming more liberalized and open, trading in futures have also become more common.

Ice is one of the main exchanges trading in natural gas futures. In 2008, total volume of futures traded was reported to be 1 262 790. Ten years later, in 2018, total volume of futures contracts were 18 687 270, (Intercontinetal Exchange, 2019) which shows a massive increase

in trading of futures contracts. For technical trading strategies to work, liquidity in the market is extremely important. Higher liquidity means that contracts can be easier bought or sold and with lower transaction costs. It also means that the market is more efficient and better reflect changes in supply and demand fundamentals. Therefore, technical trading strategies may not have worked ten years ago because of low volume and liquidity in the market but have a greater chance of giving success today.

One of the big reasons for the liberalization of the European natural gas market is to lower European countries' dependence on Russian natural gas by diversifying its suppliers and creating more competitive prices. Russia have for decades been the main supplier of natural gas to Europe, giving them market power and making several countries dependent on the delivery of natural gas from Russia. By making the natural gas market more open and freer for competition, countries and industries can choose and change their supplier more easily and therefore becoming less reliant on Russia. Even though this has been a success since a larger part of Europe have several suppliers to choose from, the export of natural gas from Russia still remains a vital part of the energy consumption in Europe. (Euractiv, (2018, May 16th)

Literature Review

In our literature review we will present an overview of the literature done in the field we are researching. By looking at the conclusions similar research have made, we will have a better base to see how our thesis will perform compared to other literature.

The Efficient Market Hypothesis

Does the current value of an asset in the financial markets reflect the true value, or is it possible for investors to profit by analyzing the past historical and fundamental information? The efficient market hypothesis dives into this, which was made by Eugene Fama(1970): An 'efficient' market is defined as a market where there are large numbers of rational, profit 'maximisers' actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants. In an efficient market, competition among the many intelligent participants leads to a situation where, at any point in time, actual prices of individual securities already reflect

the effects of information based both on events that have already occurred and on events which, of now, the market expects to take place in the future.

There are three forms of market efficiency; weak form implies that all historical information is currently priced in the market, but not all public and inside information. Semi-strong form implies that both historical and public information is currently priced in the market, while strong form implies that all information, including historical, public, and inside information is already priced in.

What the efficient market hypothesis tells us is that the market value of an asset should be very close to its intrinsic or "true" value, and so any attempt to make money from technical analysis is not going to work. There can be no "setups" or any way to make money based on a chart pattern for example, no sign that the price will rise, since that will already have been factored into the asset.

Technical analysis

Technical analysis uses historical data and price to predict future trends in financial markets. This has been widely tested in financial markets, but there is limited research in natural gas markets. **For technical trading strategies to work, it needs to be possible to make profit consistently by analyzing historical prices.** The efficient market hypothesis argues in all forms that technical trading strategies cannot provide superior returns since the historical prices have already been factored in. However, several studies testing technical trading strategies have been done, with some of them being able to generate a profit, showing that this may not be the case.

Ki-Yeol Kwon and Richard J. Kish (2002) tested the profitability of moving average strategies in the US stock market, and found that moving average strategies are profitable at the NYSE, while Gençay (1998) also found that technical trading strategies are more profitable than a simple buy-and-hold strategy trading the Dow Jones Industrial Average. Terence Lai-Leung Chong and Wing-Kam NG (2008) found that both RSI and MACD strategies were more profitable than a buy and hold strategy at the London stock exchange FT30 Index.

A study was done by Lukac et's al's(1988) where he tested 12 different technical trading strategies on 12 different futures markets consisting of foreign exchange markets, agricultural and commodity markets. Here he kept optimizing every 3 years, so the strategies that worked best the previous 3 years he would carry on to the next period, while strategies that did not work, he would not use. Then in the next period he would optimize again. Doing this he found four different strategies which were consistently profitable month to month even after the transaction costs. Bessembinder and Chan(1995) investigated if technical analysis could predict price changes in Asian stock markets and found that they could, but worked best in emerging markets like Hong Kong, Thailand, and Taiwan. On the other side, Christopher J Neely(2003) found that technical trading rules did not outperform a buy and hold strategy in the S&P 500 index when adjusted for risk. Pierre Bajgrowicz and Olivier Scaillet(2012) also says that technical trading rules don't provide economic value in the US stock market when considering transaction costs but make no conclusions on the profitability of algorithmic trading strategies of the modern age or the viability of technical trading strategies in other markets. Gunasekarage and Power (2001) researched the profitability of moving average trading rules in emerging markets in South Asia, where they found that they provided excess returns over a buy and hold strategy in 3 of the 4 markets tested. Overall, there are conflicting results on the profitability of technical trading strategies in financial markets, where both positive and negative results are found.

While the profitability of technical trading strategies in finance and equity markets have been well researched in the past, there is little to no research on trading strategies in the European natural gas market. Since the European natural gas market has seen noticeable changes in later years, the profitability of trading strategies in this market is unknown and requires substantial research and testing to make conclusions.

Price analysis in the financial markets

When it comes to analyzing the price of different assets in the financial markets there are mainly two different approaches. They are called technical analysis, and fundamental analysis. Technical analysis is an approach to analyze the financial markets that looks at past

historic data to determine the future direction. This can be done by looking at a variety of factors such as price, volume, momentum, or other market statistics. One can look at the highs/lows of the markets, the trends, the momentum at which the price is increasing/decreasing or different things. Today there are a huge amount of different ways or approaches to doing technical analysis of the financial markets. In this paper we will examine some of the most common strategies and apply them to the price data of the gas market to see how they perform there. Technical analysts do not believe that fundamental information is not important, but rather that the prices only gradually close in on its intrinsic value. As fundamentals shift, astute traders can exploit the adjustment to a new equilibrium. (Bodie, Kane and Marcus (2011), p. 400)

In comparison, fundamental analysts take a different approach to viewing the market. Fundamental analysis attempts to find the "intrinsic value" of the asset, or in other words, the true value of the asset. They do this by studying as much as they can regarding for example with stocks; looking at the industry as a whole, looking at the company's position in the market, are their customers increasing/decreasing, interpreting financial statements, reading annual reports and so on to get an impression of how the company is really doing. If they believe the true value of the company is higher than the current market value, it can be a good idea to buy that stock with the expectation that the price will increase over time since the intrinsic value is higher.

The importance of technical analysis

Steve Nison (2001) who is known for releasing books on technical analysis and introducing Japanese candlesticks to the western world, writes in his book "Japanese Candlestick Charting Techniques" that there are multiple reasons why technical analysis is important. First, there is the psychology component. He writes that fundamental analysis can give good insight to earnings, firm performance or other statistics, but there is no psychological component in an analysis like that. But that is important to have, since markets are often affected by psychology and expectations. And that the emotions and psychology can be seen clearly on a price chart.

Second, he believes that technical analysis can give order and discipline. Through technical analysis and looking at a price chart, one can see clearly where the price has previously been

and set expected entry points, exit points, measure if a risk is worth taking based on risk/reward ratio and so forth. Then when the price approaches a certain level, one can have some idea of what has happened when it was here previously by looking at the chart. By having already pre-defined entry/exit points for example it should be easier to stay disciplined rather than making spontaneous decisions with trading.

Another reason technical analysis is important is because technical levels can be the reason that the market does a particular move. Technical analysis is also important because it is the most direct and easily accessible method of seeing overall supply/demand relationships in the market.

Figure 3: An example of a daily price chart with Japanese candlesticks of AUD/USD

Method

For our thesis we will test different technical trading strategies used in financial markets today. We will test various variations of the well-documented strategies moving average strategy and Relative Strength Index (RSI). For these strategies to perform as good as possible, we want to trade them in markets that are as liquid as possible so the contracts can be quickly bought or sold with low transaction costs. We will therefore test these strategies in the three most liquid gas hubs in Europe, which are TTF, NBP, and NCG.

Moving average trading strategies exist in many different forms and variations. The ones used in this thesis are a simple moving average crossover strategy, exponential moving average crossover strategy, and a mix of the two. We will also incorporate RSI with these strategies in different ways.

The idea behind a moving average is to remove "noise" from the price information retrieved, and make the price data smoother, therefore making it easier to spot trends in the market. (Investopedia, 2019, June 8th)

In this chapter we will also show how we calculate the returns of our portfolio, which constraints we face with our trading, and which measurements we use to analyze the performance of the trading strategies.

Risk-free rate

In theory, a risk-free rate is the rate of return achieved from an investment with zero risk. In other words, it is what an investor can expect to receive in return from an investment with zero risk over a specific period. (Investopedia, 2018, August 29th)
In practice it doesn't work that way though, since it is hard to find an investment that is entirely risk-free. It is therefore common to use a national bond as a reference for a risk-free rate, since national bonds, specifically those from low risk economies, have an extremely low chance of forfeiting payment, and are therefore the closest you can get to a risk-free investment in the real world. US 10-year bonds is a common rate used for a risk-free rate, but since Westgass AS is a Norwegian company, we have calculated a risk-free rate from 10-year Norwegian national bonds. From 2017, the 10-year bond have an average yield of 1,6075% during the time we tested, 2018 averages 1,88%, and 2019 averages 1,7830% from the period tested. In a weighted average over the time period analyzed, the calculated yearly risk-free rate is 1,8218%. The risk-free rate for the entire period tested is calculated to be 2,2803%. The risk-free rate is an important value for analyzing the performance of investments since it is used in several different measurement tools like Sharpe ratio and Treynor ratio. (Norges Bank, s.a)

Risk and performance measures

When considering the quality of a trading strategy, the risk involved is very important. If a strategy gives high returns, but also has very high risk, it may be better to choose a different strategy depending on the investors' preferences. To measure the risk and performance of the different strategies, we measure the standard deviation and Sharpe ratio of each strategy.

Standard deviation tells us how much the returns of the strategy varies relative to the mean, while the Sharpe ratio is a tool to measure the return of an investment compared to its risk.

There are several methods of measuring risk and performance. Some common methods of measuring performance are the Sharpe ratio, Treynor ratio, Jensen's alpha.

The Sharpe ratio is the most common method for measuring performance. It is a method of providing risk adjusted return, and describes the extra return gained over the risk-free rate per unit of risk.

$$Sharpe\ Ratio = \frac{Rp - Rf}{\sigma p}$$

Equation 1: Sharpe Ratio (Wallstreetmojo, s.a)

Treynor ratio is very similar to Sharpe and measures the return over volatility. The main difference between the two methods is that Treynor uses the portfolio's beta instead of the standard deviation.

$$Treynor\ Ratio = \frac{Rp - Rf}{\beta p}$$

Equation 2: Treynor Ratio (Wallstreetmojo, s.a)

Jensen's alpha measures the return of a portfolio against a benchmark and calculate in its risk. The alpha calculated gives information about the performance of the portfolio compared to the risk taken. An alpha<0 means the return is too low compared to the risk taken, an alpha=0 means the return is enough compared to the risk taken, and an alpha>1 means the portfolio gives higher returns than the risk taken assumes. (Wallstreetmojo, s.a)

$$Jensen's\ \alpha = Rp - Rf - \beta p(Rm - Rf)$$

Equation 3: Jensen's Alpha (Wallstreetmojo, s.a)

The main method to measure risk is the standard deviation, which is a statistic that measures the dispersion of a dataset relative to its mean and is calculated as the square root of the variance(Investopedia, 2019, May 25th). In finance this shows us the volatility of the asset. The lower the standard deviation is, the better(more stable and less volatile) while a higher standard deviation implies more volatility, more variety amongst the returns and higher risk. The formula for standard deviation is

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n-1}}$$

where:

x_i = Value of the i^{th} point in the data set

$\overline{x}$ = The mean value of the data set

n = The number of data points in the data set

Equation 4: Standard Deviation (Investopedia, 2019, May 25th)

In this thesis we will to use the Sharpe ratio as a performance measure, and standard deviation as the risk measure. Sharpe ratio is the most widely used method for measuring performance and will therefore be a good option when we will analyze the performance of our strategies. We want the standard deviation to be as low as possible, while we want the Sharpe ratio to be as high as possible. To measure the performance, we will compare the resulting performance and risk measures from our strategies to those of the buy and hold strategy.

Different contracts in natural gas hubs

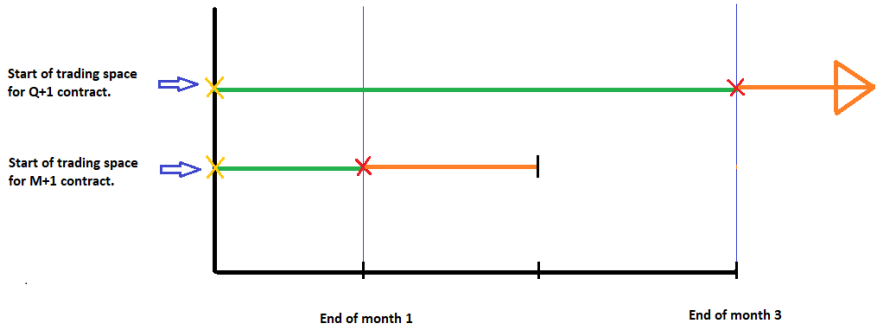

Figure 4: Trading space of forward contracts of natural gas. Shows the trading space of the quarter-ahead and month-ahead forward contracts. The green line shows the space when the contracts can be traded as a financial asset, while the orange line shows when the gas gets delivered or bought.

There are many different forward contracts traded at the different gas hubs in Europe. The most common are day-ahead, month-ahead, and quarter-ahead, but there is also season-ahead and year-ahead. If for example a day-ahead contracted is purchased, the owner of the contract receives natural gas the following day. While a month-ahead contract delivers natural gas the following month and so forth. There also exists month+2 for example which means the gas is delivered two months ahead. All these contracts are priced differently depending on what type of contract it is, the expected demand and supply of natural gas, and many other factors which can be hard to pinpoint. One way of implementing a trading strategy using these contracts would be to treat them like a financial contract close to stocks and other equities. However, trading day-ahead and month-ahead contracts can be problematic since they have a small trading window before the contracts are executed. Therefore quarter-ahead contracts are a preferred choice because they give a bigger trading window where they can be traded without executing the contract and they are also liquid enough to trade.

The time constraint we face trading gas

Using the quarter ahead data we have some constraints on how to buy/sell the gas, and one of them is the time constraint. When we buy or sell gas during a quarter, we must make sure we

close the position **before** the quarter ends, if not, the contract is set in motion and we are forced to deliver the following quarter. This is not what we want as we are testing trading strategies thinking of the gas as a normal financial asset, and to avoid this we must make sure to close the position before the quarter ends. Therefore, a part of our strategy using these technical analysis tools when trading is to do a "forced" close at the end of the quarter. If we're in a position, we decide to close it before the month ends no matter what, irrelevant of the trading signals. And we take that profit/loss with forced closes into our statistics of the trading strategies.

How we calculate the returns:

In our excel files we have the value of our portfolio, which we have set to 1 as the starting capital. We get all our entries and most of our closes from the signals generated by the various trading strategies, with some exceptions at the end of the quarters where we are forced to close the position as described above.

Whenever a signal is given, we enter the trade on the same day. The position is then open until we get a signal to exit, or we're at the end of the quarter in which case we close it.

To calculate the return of the portfolio we do the following: If we get a signal to buy, we take the closing price divided by the entry price. We then get a return which we multiply by the investment amount. And if we get a signal to sell, we divide in the opposite direction. For example, if we have an open buy position where we bought gas for 20.546 and got a signal to sell again for 21.184, we would divide 21.184 by 20.546 and get the return = 1.031(3,1%). To calculate the return into the portfolio we multiply the return by the value of the current portfolio. If this is the first trade, the value of our portfolio before the trade would be 1. To calculate in the return, we multiply 1(value of portfolio) by 1.031 giving us a portfolio of 1.031.

Then in the next position, we calculate returns the same way, but multiply the return with the new portfolio value which would in this case be 1.031.

The average return we find for each strategy, is done by taking all the returns from the same strategy on the different hubs and dividing by the amount.

Moving averages in financial markets

Moving averages are a commonly used tool in financial markets and can be used in many ways. One strategy utilizing the moving average tool is called the moving average crossover strategy, where we have two moving averages, one short and one long. These two moving averages can be how long or short that is needed, but one must be longer than the other. When these two moving averages crossover in value, an investor can either go long or short depending on how the strategy is formed.

Figure 5: Moving average crossover(babypips, s.a)

The idea behind a moving average crossover strategy is to profit from trends in the market. For example, when the short moving average is higher than the long moving average, this means that there is an upward trend in the market. If an investor buys an asset in the market when this happens, and the trend continues, his open position is now in profit. When the opposite happens, and the short moving average moves below the long moving average, this signals a downward trend in the market, and shorting assets will make profit if the trend continues.

Equation for a simple moving average(SMA):

Simple moving average = (P1 + P2 + P3 + P4 +...+ Pn)/n Where P = price

Equation 5: Simple moving average(The Balance, 2018, December 31st)

Exponential moving average (EMA) is another moving average tool that takes the exponential moving average instead of the simple moving average. Exponential moving average gives more weighting to recent price data and will therefore react quicker to price changes than the simple moving average. It uses the same rules as a simple moving average strategy where it uses a long line and a short line where a crossover gives either a buy signal or a sell signal depending on how it crosses and how the strategy is formed. An exponential moving average has an advantage because it should identify new trends sooner, but may also give false signals, which means that it can signal a trend, when this is not the case.

Equation for exponential moving average:

Exponential moving average = (close - previous EMA) * (2/n+1) + previous EMA

Equation 6: Exponential moving average(The Balance, 2018, December 31st)

It is also possible to combine the two moving averages to make a "hybrid" moving average strategy. It is logical to use the exponential moving average as the short moving average, and the simple moving average as the long moving average. This means that recent price changes will have an even larger effect on the short moving average, than the long moving average, and hopefully predict trends in the market sooner. All of these moving averages can be combined with RSI as well as other technical tools to give different results.

RSI:

The RSI is a momentum oscillator which shows how much momentum the price has on a scale from 1-100. It was originally developed by J. Welles Wilder Jr. and introduced in his book New concepts in technical trading systems which came out in 1978. (J. Welles Wilder Jr, (1978)) He describes a few different ways here to interpret the RSI including tops and bottoms, chart formations, failure swings, support and resistance on the RSI oscillator and so on. For our technical trading strategies however, we will focus on one aspect of this, which is what the oscillator is telling us in relation to the price's momentum.

The oscillator shows a number of 1-100. A number over 50 indicates that the price has bullish momentum, while a number under 50 tells us that it has bearish momentum. In addition to this, there are some upper and lower "boundaries". J.Welles Wilder describes in his book that if the price reaches above 70, a "top" might form, the asset is then overbought, and a reversal might come. While if it goes underneath 30, a "bottom" might form, and so the asset is oversold and soon a reversal might come. These were the overbought/oversold conditions J. Welles Wilder described in his original book – but more modern traders have also extended the levels to 20/80 as the overbought/oversold parameters instead of 70/30 depending on the asset class, the timeframe, and so on. (Source)

We have used three different variants of the RSI filter when testing our strategies. The first RSI filter we tested, which we have called the RSI 50/50 filter, only incorporates if the price is above or below 50 as we want the momentum to be on our side. So, if we get a signal to buy gas, but the RSI showed bearish momentum(under 50), that signal will be filtered out and we will not take it. If however we get a buy signal and the momentum is on our side(above 50, bullish) then we will take the trade. And the same goes in the opposite direction: We have used the RSI to filter out some signals, so we only take short signals when the momentum is bearish(under 50).

In the second variant we have tested, which we call the RSI 70/30 filter – we include the overbought and oversold boundaries. Here we keep the rule from the previous filter, that the momentum must be over/below 50 and on our side – in addition to excluding buy signals when the RSI is over 70, and excluding short signals when the RSI is under 30. If we follow J. Welles Wilder's theory – a "top" or a "bottom" in the market might soon come, and so we don't want to take the trade. Here a lot of the trades get filtered out as using this RSI method asks for very specific momentum – with this applied, we only buy gas if we get a signal and the RSI is between 50-70, and we only sell gas if we get a signal and the RSI is between 20-50.

The RSI 80/20 filter is the final variant we have tested. Here we use the same rules as above, including that the momentum must be over/below 50 and in our favor, and the overbought/oversold conditions. But here we extend the overbought conditions from 70 to 80 and the oversold conditions from 30 to 20. We didn't know which filter would work best for gas, and so we decided to test it. With these extended conditions this method filters out a little

less trades than the RSI 70/30 filter, and in many of our results we can see that the they are improved.

The RSI signal is incorporated into both our entries and our exits. Our entries are as described above, and we only choose to exit when we get a signal and the price is showing momentum against our position. So for example if we have a current buy position, we will only exit the trade when we get a short signal in addition to the price showing bearish momentum.

There are many different ways to use the RSI oscillator as a filter. Testing these three filters we have gotten good insight into what compliments our moving average crossovers strategies, and which RSI filter works best for the gas market.

How the RSI is calculated:

$$\textbf{RSI} = 100 - \left[\frac{100}{1 + RS} \right]$$

$$\textbf{RS} = \frac{\text{Average Upward Movement}}{\text{Average Downward Movement}}$$

Equation 7: RSI and RS

Average Upward Movement and **Average Downward Movement** is the average of the last 14 movements. If on 12th of October 2017 the daily close was 19800, and on the 13th of October 2017 it was 20029, then the Upward Movement was 0.229. Since there was no downward movement, here that would be 0. So, if today's price is bigger than yesterday's price, there is an upward movement, while if the opposite is true then there is a downward movement. And whenever there is an upward movement, logically there is no downward movement that day. So, when one has a value, the other one is 0 as we can see in the example here.

nbp-prices-quarter-1				
NBP Continental Price Assessments Quarter +1 Bid/Offer Range (Mid) : EUR/MWh	Upward Movement	Downward Movement	Average Upward Movement	Average Downward Movement
20.007			14	14
19.939				
20.005	0.066	0		
19.885	0	0.12		
19.829	0	0.056		
19.800	0	0.029		
20.029	0.229	0		
20.090	0.061	0		
20.046	0	0.044		
20.261	0.215	0		
19.970	0	0.291		
19.622	0	0.348		
19.504	0	0.118		
19.394	0	0.11		
19.531	0.137	0		
19.553	0.022	0	0.052142857	0.079714286

Figure 6: Example of RSI in Excel

And only when we have 14 observations of the upwards and downwards movements, we can find the average movements and further go on to calculate the RS and the RSI.

Transaction cost

When trading futures contracts, transaction costs are applied both when buying and selling the contract. This of course has a direct effect on the returns on the trading strategies. The transaction charges are provided by Powernext and are different between the gas hubs.

Market	Currency	Total	
TTF	€/MWh	0.0245	
NCG	€/MWh	0.025	In €/MWh:
NBP	GBPpence/therm	0.0213	0.008

Table 4: Transaction costs

To make the returns of the different strategies as realistic as possible, the transaction costs are calculated in the strategies.

Signals

A signal says when you should trade the contract in the market. A buy signal means you should buy the contract, and a sell signal means you should sell the contract. The signals are provided by the moving average crossovers used in the strategy. In this paper we have used two different datasets to create our signals which are the day-ahead prices, and the quarter-ahead prices. The day-ahead prices are the spot prices in the market and the quarter-ahead prices give a more forward-looking outlook since they represent the prices for natural gas the following quarter. Arguments for using the spot signal are that they are the main price drivers for the quarter-ahead contracts we trade, and therefore should provide trends in the market. However, they also show short-term noise that are not relevant for the quarter-ahead contracts. Because of that, using the quarter-ahead prices as a signal takes away that noise, and show the prices of the contracts we trade, and provide more long-term price movements. By using both as signals, and comparing the results, we will see a more complete result of the competitiveness of the trading strategies.

Data

We received all price data used in this paper from Westgass AS. Our analysis is done over a period of almost 15 months, from October 5th, 2017 to January 29th , 2019. We have analyzed the daily price data for day-ahead contracts and quarter-ahead contracts for all three natural gas hubs used in our analysis, which are the NBP, NCG, and TTF natural gas hubs.

Results

SMA strategies

From our analysis we will go through the our results of the strategies and will start with the simple moving average(SMA) crossover strategies.

Returns

We will now look at the returns of all our strategies in isolation before we start adding in risk and performance measures. First we will see which dataset provided the best signals for our strategies, spot vs quarter, then we will look into which RSI filter worked best compared to using no filter, then which SMA strategy performed best across the different RSI filter or no filter methods – and finally all our results and how they compare to the buy and hold strategy.

Returns	**Spot**	**Q+1**	**Average**	Ranking
No RSI	-0.0986	0.0234	-0.0376	**4**
RSI 50/50	0.1699	0.0798	0.1249	**3**
RSI 70/30	0.1781	0.0805	0.1293	**2**
RSI 80/20	0.1853	0.0872	0.1362	**1**
Average	0.1087	0.0677		
Ranking	**1**	**2**		

Table 5: Simple moving average returns

First, we'll look at which dataset fit our strategies best. From the table above we can see that using the RSI filters the spot signals clearly outperform the quarter signals, delivering at least 2x the average return with all the different RSI settings. Without RSI however the average results using the spot data is quite negative at -0.0986, while analyzing the quarter signals give slightly positive results. Using no RSI, the SMA strategies utilizing the quarter signals give the better results, while using RSI and analyzing the spot data gives the best results and overall significantly better returns.

When it comes to using only the signals or using RSI with the different settings, we can see from the data we have which RSI filter gives the most return and which give the least. The RSI 50/50 method give the least return in average with all the different SMA strategies and across all the hubs, both using the spot data for signals and using the quarter data. The RSI 70/30 method outperforms the 50/50 when it comes to return, ranking second in average return both using the quarter signals and using the spot signals. RSI 80/20 performs best out of the three when it comes to returns, and all the RSI filters manage to outperform the strategies using only the signals. And so, we can conclude that utilizing the RSI filter is beneficial when it comes to the SMA strategies.

Now we'll look at which strategy seems to work best both with and without RSI.

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI 80/20**			
Strategy	**Spot**	**Q+1**	**Spot**	**Q+1**	**Spot**	**Q+1**	**Spot**	**Q+1**	**Average**	**Rank**
Buy and hold									0.1719	2
(5)>(20)	0.0719	0.1429	0.1861	0.1726	0.2160	0.17327	0.216	0.1733	0.1690	3

(1)>(10)	-0.2471	-0.0605	0.0634	-0.1276	0.0948	-0.1047	0.0948	-0.1276	-0.0518	6
(1)>(20)	-0.2132	0.1361	0.1812	-0.2867	0.1812	-0.2505	0.1812	-0.2505	-0.0401	5
(2)>(10)	-0.1804	0.0393	0.2489	0.1362	0.2453	0.13624	0.2707	0.1362	0.1291	4
(5)>(10)	0.0760	-0.1409	0.1697	0.5047	0.1533	0.44821	0.1636	0.5047	0.2349	1

Table 6: Simple moving average returns

From the above column we can see that the SMA(5)>SMA(10) strategy is the SMA strategy that works best across the different methods, and by a large margin. It has 23.4926% while the buy and hold strategy comes closest with 17.19% return. The SMA(5)>SMA(10) provides a 50.47% return using the RSI 50/50 and the RSI 80/20 filters, which is quite good compared to benchmark. Using no RSI give positive returns when analyzing the spot signals, but negative when analyzing the quarter signals.

In this paper we will see here and in some other examples that the RSI 50/50 filter and the RSI 80/20 filter in some cases give the same returns or risk measures. This is because both use the same signals, both use one of the constraints which is that for the signals to turn in to a buy/sell position the RSI must be over 50 to buy, or under 50 to sell. The RSI 80/20 filter has an extra constraint, that if the RSI is over 80 while a sell signal comes the signal will not be taken, and if it is under 20 when a buy signal comes that will not be taken. So, the same returns/risks in some cases just means that using that particular SMA strategy, there never came a signal when the RSI was over 80 or under 20 and so they used the same constraints.

Using RSI, the SMA(5)>SMA(10) strategy gave overall the biggest returns, while using no RSI none of the SMA strategies could in average outperform a buy and hold strategy. We can see that from the table below.

No RSI returns					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** **Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**1**
SMA(5)>SMA(20)	0.0854	0.0809	0.0494	0.0719	**3**
SMA(1)>SMA(10)	-0.1181	-0.3573	-0.2660	-0.2471	**6**
SMA(1)>SMA(20)	-0.1131	-0.2079	-0.3185	-0.2132	**5**
SMA(2)>SMA(10)	-0.1585	-0.2858	-0.0971	-0.1805	**4**
SMA(5)>SMA(10)	0.0055	0.1585	0.0640	0.0760	**2**
Average	**-0.0598**	**-0.1223**	**-0.1136**		

Quarter signal	NBP	NCG	TTF	Average across all hubs Signal (Q+1)	Ranking
Buy and hold	0.1480	0.1793	0.1882	0.1719	**1**
SMA(5)>SMA(20)	**0.1719**	0.1207	0.1362	0.1429	**2**
SMA(1)>SMA(10)	0.0103	-0.1448	-0.0469	-0.0605	**5**
SMA(1)>SMA(20)	**0.2831**	0.0287	0.0965	0.1361	**3**
SMA(2)>SMA(10)	0.0262	-0.0024	0.0942	0.0393	**4**
SMA(5)>SMA(10)	-0.0918	-0.1143	-0.2165	-0.1409	**6**
Average	**0.0799**	**-0.0224**	**0.0127**	**0.0234**	

RSI 50/50 Returns					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**4**
SMA(5)>SMA(20)	0.1886	0.3603	0.0093	0.1861	**2**
SMA(1)>SMA(10)	0.4969	-0.0605	-0.2462	0.0634	**6**
SMA(1)>SMA(20)	0.2338	0.3542	-0.0444	0.1812	**3**
SMA(2)>SMA(10)	0.3513	0.4001	-0.0045	0.2489	**1**
SMA(5)>SMA(10)	-0.3028	0.5072	0.3048	0.1697	**5**
Average	**0.1935**	**0.3123**	**0.0038**	**0.1699**	
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**3**
SMA(5)>SMA(20)	0.2773	0.1305	0.1100	0.1726	**2**
SMA(1)>SMA(10)	0.0684	-0.2538	-0.1976	-0.1276	**5**
SMA(1)>SMA(20)	-0.3031	-0.2533	-0.3037	-0.2867	**6**
SMA(2)>SMA(10)	0.7420	-0.2178	-0.1154	0.1362	**4**
SMA(5)>SMA(10)	0.4884	0.4575	0.5682	0.5047	**1**
Average	0.2546	-0.0274	0.0123	0.0798	

RSI 70/30 Returns					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**4**
SMA(5)>SMA(20)	0.1886	0.4062	0.0531	0.2160	**2**
SMA(1)>SMA(10)	0.5398	-0.0320	-0.2233	0.0948	**6**
SMA(1)>SMA(20)	0.2338	0.3542	-0.0444	0.1812	**3**
SMA(2)>SMA(10)	0.4165	0.3238	-0.0045	0.2453	**1**
SMA(5)>SMA(10)	-0.2917	0.4754	0.2763	0.1533	**5**
Average	**0.2174**	**0.3055**	**0.0114**	**0.1781**	

RSI 70/30					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**3**
SMA(5)>SMA(20)	0.2773	0.1282	0.1143	0.1733	**2**
SMA(1)>SMA(10)	0.0684	-0.1868	-0.1958	-0.1047	**5**
SMA(1)>SMA(20)	-0.3031	-0.1853	-0.2631	-0.2505	**6**
SMA(2)>SMA(10)	0.7420	-0.2178	-0.1154	0.1362	**4**
SMA(5)>SMA(10)	0.4874	0.4575	0.3998	0.4482	**1**
Average	**0.2544**	**-0.0009**	**-0.0120**	**0.0805**	

RSI 80/20 Returns					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**4**
SMA(5)>SMA(20)	0.1886	0.4062	0.0531	0.2160	**2**
SMA(1)>SMA(10)	0.5398	-0.0320	-0.2233	0.0948	**6**
SMA(1)>SMA(20)	0.2338	0.3542	-0.0444	0.1812	**3**
SMA(2)>SMA(10)	0.4165	0.4001	-0.0045	0.2707	**1**
SMA(5)>SMA(10)	-0.2389	0.4754	0.2544	0.1636	**5**
Average	**0.2280**	**0.3208**	**0.0071**	**0.1853**	
RSI 80/20 Std					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	0.1719	**3**
SMA(5)>SMA(20)	0.2773	0.1282	0.1143	0.1733	**2**
SMA(1)>SMA(10)	0.0684	-0.2538	-0.1976	-0.1276	**5**
SMA(1)>SMA(20)	-0.3031	-0.1853	-0.2631	-0.2505	**6**
SMA(2)>SMA(10)	0.7420	-0.2178	-0.1154	0.1362	**4**
SMA(5)>SMA(10)	0.4884	0.4575	0.5682	0.5047	**1**
Average	**0.2546**	**-0.0142**	**0.0213**	**0.0872**	

Table 7: Simple moving average returns

Using no RSI none of the SMA strategies could in average beat the buy and hold strategy, but the SMA(5)>SMA(20) strategy analyzing the quarter signals come close with a 14.29% portfolio return vs a 17.19% portfolio return from buy and hold.

When it comes to the strategies with RSI, with the 50/50 filter and the quarter signals the average results across all the different hubs are quite inconsistent. They range from -0.2867 with the SMA(1)>SMA(20) strategy to a return of 0.5047 from the SMA(5)>SMA(10) strategy. This strategy gives a return of above 0.45 on all the three different hubs so that's

good. So here with the RSI filter and SMA strategies, backtesting shows that the results are inconsistent.

The spot data is somewhat more consistent if we look at the average return across all the hubs. It is positive, but still inconsistent ranging from 0.0948 to 0.2707. The average return is also better here.

For the 70/30 and the 80/20 filters the results are not much different. The results analyzing the quarter signals have a bigger range, ranging with a return from around -0.25 to above 0.44 with both of those filters. If we look at the different SMA strategies on the spot signals, the average return across the three different hubs are again all positive analyzing the spot signals, and the average returns across all hubs with all strategies are in average at least 2x higher than if we utilized the quarter signals. We will now look at which strategy performed best out of the SMA strategies:

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI 80/20**			
Strategy	**Spot**	**Q+1**	**Spot**	**Q+1**	**Spot**	**Q+1**	**Spot**	**Q+1**	**Average**	**Rank**
B&H									0.1719	2
(5)>(20)	0.0719	0.1429	0.1861	0.1726	0.2160	0.1733	0.2160	0.1733	0.1690	3
(1)>(10)	-0.2471	-0.0605	0.0634	-0.1276	0.0948	-0.1047	0.0948	-0.1276	-0.0518	6
(1)>(20)	-0.2132	0.1361	0.1812	-0.2867	0.1812	-0.2505	0.1812	-0.2505	-0.0402	5
(2)>(10)	-0.1804	0.0393	0.2489	0.1362	0.2453	0.1362	0.2707	0.1362	0.1291	4
(5)>(10)	0.0760	-0.1409	0.1697	0.5047	0.1533	0.4482	0.1636	0.5047	0.2349	1

Table 8: Simple moving average returns

As we can see from the column above on average across all the hubs and with/without the RSI filters the SMA(5)>SMA(10) strategy performs best overall. The average returns are better than the benchmark, and it is the only strategy that manages to outperform it. The returns with the RSI filters and from the quarter signals which come in at 0.5047, 0.4482 and 0.5047 respectively show the best returns.

Using no RSI, we can see that the SMA(1)>SMA(20) is the strategy that performs best, coming in as the second-best strategy analyzing both the quarter signals and the spot signals, and it has the best average.

To sum up, we have found that for the SMA strategies, utilizing the spot data gave the best returns with RSI, and utilizing the quarter signals fit the strategies best without RSI. We have found that further using an RSI filter was overall beneficial for these SMA strategies, as they all outperformed the strategies using no filter. And out of the RSI filters, the RSI 80/20 performed best, with the 70/30 filter second, and no filter third. The SMA(5)>SMA(10) strategy came in with the best returns across the different hubs and different RSI filters, while the SMA(1)>SMA(20) strategy worked best without RSI.

what we have seen here is that utilizing only the signals without RSI, the results in average do not beat a buy and hold strategy. A few strategies did – and that was specifically the SMA(5)>SMA(20) and SMA (1)>SMA(20) strategies analyzing the quarter data and trading at the NBP hub. Across all the hubs though those strategies still did not beat the buy and hold.

When it comes to the SMA strategies with the RSI filters, the results are different. A lot of them managed to beat the buy and hold strategy. With all the three different filters and analyzing the spot signals, 3/5 of the SMA strategies across all hubs managed to beat the average return of the buy and hold strategy. Utilizing the quarter data for signals, only 2/5 managed to beat the buy and hold strategy.

Risk measure

Now that we've taken a look at the returns of our strategies, we will look more closely at the risk measures. As described earlier in the paper we have decided to use the standard deviation for our risk measure, and in this chapter we will examine the standard deviation of our strategies.

St.dev	Spot	Q+1	Average	Ranking
No RSI	0.0219	0.0195	0.0207	**4**
RSI 50/50	0.0200	0.0199	0.0199	**1**
RSI 70/30	0.0200	0.0201	0.0201	**3**
RSI 80/20	0.0200	0.0200	0.0200	**2**
Average	0.0205	0.0199		
Ranking	**2**	**1**		

Table 9: Standard deviation results for the simple moving average strategies

We will first look at which dataset gave the signals with lower risk, before looking at whether using RSI or no RSI was riskier, then we will finally look at how our strategies' risk compares

to the buy and hold strategies. With standard deviation a lower number is better, as we prefer a lower amount of risk.

From the table above we can see that the spot and quarterly data have quite similar risk. In average from all the strategies across the hubs, the spot data has a volatility of 0.0205 and analyzing the quarter data has a standard deviation of 0.0199. And so, if we look at just the risk, utilizing the quarter ahead signals give in average the best results.

From the same table, we can see the ranking of the different RSI filters and the strategies utilizing simple moving average signals only. As we can see, all of the RSI filters help reduce the risk, as utilizing the signals in isolation gives the highest volatility. Here the RSI filter that ranks best is 50/50, followed by 80/20 second and 70/30 last. As with the returns, we can conclude that using an RSI filter is beneficial. We will now continue to see how our risk results compare to the buy and hold strategies.

No RSI Std					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**5**
SMA(5)>SMA(20)	0.0184	0.0686	0.0179	0.0350	**6**
SMA(1)>SMA(10)	0.0180	0.0187	0.0175	0.0180	**2**
SMA(1)>SMA(20)	0.0182	0.0187	0.0204	0.0191	**3**
SMA(2)>SMA(10)	0.0168	0.0186	0.0179	0.0178	**1**
SMA(5)>SMA(10)	0.0187	0.0202	0.0199	0.0196	**4**
Average	**0.0180**	**0.0290**	**0.0187**	**0.0219**	
No RSI Std					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
SMA(5)>SMA(20)	0.0196	0.0136	0.0190	0.0174	**1**
SMA(1)>SMA(10)	0.0178	0.0178	0.0178	0.0178	**2**
SMA(1)>SMA(20)	0.0234	0.0236	0.0225	0.0232	**6**
SMA(2)>SMA(10)	0.0182	0.0175	0.0178	0.0179	**3**
SMA(5)>SMA(10)	0.0207	0.0220	0.0210	0.0212	**5**
Average	**0.0199**	**0.0189**	**0.0196**	**0.0195**	

RSI 50/50 Std					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (spot)	Ranking
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
SMA(5)>SMA(20)	0.0188	0.0214	0.0246	0.0216	**6**

SMA(1)>SMA(10)	0.0208	0.0202	0.0224	0.0211	**5**
SMA(1)>SMA(20)	0.0211	0.0188	0.0183	0.0194	**3**
SMA(2)>SMA(10)	0.0176	0.0176	0.0208	0.0187	**1**
SMA(5)>SMA(10)	0.0209	0.0179	0.0189	0.0192	**2**
Average	**0.0198**	**0.0192**	**0.0210**	**0.0200**	
RSI 50/50 Std					
Quarter signal	**NBP**	**NCG**	**TTF**	Average across all hubs Signal (Q+1)	Ranking
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
SMA(5)>SMA(20)	0.0190	0.0176	0.0176	0.0181	**1**
SMA(1)>SMA(10)	0.0213	0.0194	0.0190	0.0199	**3**
SMA(1)>SMA(20)	0.0233	0.0210	0.0226	0.0223	**6**
SMA(2)>SMA(10)	0.0236	0.0189	0.0202	0.0209	**5**
SMA(5)>SMA(10)	0.0201	0.0157	0.0188	0.0182	**2**
Average	**0.0215**	**0.0185**	**0.0196**	**0.0199**	

RSI 70/30 Std					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
SMA(5)>SMA(20)	0.0188	0.0216	0.0249	0.0218	**6**
SMA(1)>SMA(10)	0.0207	0.0201	0.0224	0.0211	**5**
SMA(1)>SMA(20)	0.0211	0.0188	0.0183	0.0194	**3**
SMA(2)>SMA(10)	0.0174	0.0189	0.0208	0.0190	**2**
SMA(5)>SMA(10)	0.0197	0.0174	0.0197	0.0189	**1**
Average	**0.0195**	**0.0193**	**0.0212**	**0.0200**	
RSI 70/30 Std					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
SMA(5)>SMA(20)	0.0190	0.0186	0.0183	0.0186	**1**
SMA(1)>SMA(10)	0.0213	0.0190	0.0204	0.0202	**4**
SMA(1)>SMA(20)	0.0233	0.0208	0.0225	0.0222	**6**
SMA(2)>SMA(10)	0.0236	0.0189	0.0202	0.0209	**5**
SMA(5)>SMA(10)	0.0208	0.0157	0.0196	0.0187	**2**
Average	**0.0216**	**0.0186**	**0.0202**	**0.0201**	

RSI 80/20 Std					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
SMA(5)>SMA(20)	0.0188	0.0216	0.0249	0.0218	**6**
SMA(1)>SMA(10)	0.0207	0.0201	0.0224	0.0211	**5**

SMA(1)>SMA(20)	0.0211	0.0188	0.0183	0.0194	**3**
SMA(2)>SMA(10)	0.0174	0.0176	0.0208	0.0186	**1**
SMA(5)>SMA(10)	0.0207	0.0174	0.0190	0.0190	**2**
Average	**0.0197**	**0.0191**	**0.0211**	**0.0200**	
RSI 80/20 Std					
Quarter signal	**Average across all hubs**				
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
SMA(5)>SMA(20)	0.0190	0.0186	0.0183	0.0186	**2**
SMA(1)>SMA(10)	0.0213	0.0194	0.0190	0.0199	**3**
SMA(1)>SMA(20)	0.0233	0.0208	0.0225	0.0222	**6**
SMA(2)>SMA(10)	0.0236	0.0189	0.0202	0.0209	**5**
SMA(5)>SMA(10)	0.0201	0.0157	0.0188	0.0182	**1**
Average	**0.0215**	**0.0187**	**0.0198**	**0.0200**	

Table 10: Standard deviation results for simple moving average strategies

Overall the risk we see from our strategies is quite consistent, with most of them hovering around 0.02.

If we compare our SMA strategies' risk without the RSI filter, they perform quite well. Analyzing the spot data, 4/5 of the SMA strategies have a better risk measure than the buy and hold strategy. Utilizing the quarter signals, it is slightly worse but 3/5 still manage to outperform the buy and hold. Something here which is a bit odd is that the strategy that gives the highest risk with the spot signals, the SMA(5)>SMA(20) actually gives the lowest risk with the quarter signals.

Looking at the risk in isolation, more than half of the no-RSI strategies manage to outperform the buy and hold strategy which is good.

When it comes to the RSI filters they generally perform quite well also. With the RSI 50/50 filter and, 3/5 of the SMA strategies analyzing both the spot and the quarter data manage to outperform the buy and hold strategy.

The RSI 70/30 results come in pretty much the same. 3/5 of the SMA strategies analyzing the spot data outperform the buy and hold, while analyzing the quarter data only 2/5 come in less than the buy and hold. And finally, with the RSI 80/20 filter, 3/5 of the strategies outperform the buy and hold analyzing both the datasets. Same as the RSI 50/50 here. We will now look at which of the SMA strategies give the average lowest standard deviation both with/without RSI and across the hubs.

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI**	

							80/20			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
(5)>(20)	0.0186	0.0201	0.0216	0.0181	0.0218	0.0186	0.0218	0.0186	0.0199	**2**
(1)>(10)	0.0199	0.0206	0.0211	0.0199	0.0211	0.0202	0.0211	0.0199	0.0205	**4**
(1)>(20)	0.0222	0.0208	0.0194	0.0223	0.0194	0.0222	0.0194	0.0222	0.0210	**5**
(2)>(10)	0.0209	0.0198	0.0187	0.0209	0.0190	0.0209	0.0186	0.0209	0.0200	**3**
(5)>(10)	0.0182	0.0187	0.0192	0.0182	0.0189	0.0187	0.0190	0.0182	0.0187	**1**

Table 11: Standard deviation results for simple moving average strategies

From the different SMA strategies, we can see that the SMA (5)>(10) strategy provides the lowest average standard deviation. It has a standard deviation of 0.0187, while the SMA(5)>(20) has the second lowest risk at 0.0199. Furthermore, the SMA(1)>SMA(20) is the strategy with the highest volatility of these, coming in with an average of 0.021.

What we have found so far from looking at the risk measures is that out of the datasets, the quarter signals give the least risk and is the most favorable one, while the spot signals have in average only slightly higher risk.

When we compare our strategies' risk to the buy and hold strategy, the trading strategies measure up surprisingly well. One would naturally expect the risk of a buy and hold strategy to be a lot lower than trading and being in/out of positions actively. Using no RSI filter, 4/5 out of the SMA strategies had lower risk than the buy and hold, and using RSI for the most part 3/5 strategies in average managed to outperform the buy and hold, one case analyzing the quarter data with the RSI 70/30 filter only 2/5 had a lower risk.

Performance measure

Now that we've looked at returns and risk in isolation we will continue and look at how good the returns are when considering the risk taken on the different strategies. To measure this, we will look at the results from our tests using the Sharpe ratio, and here a higher number is better. We will start by looking at which signals, spot or quarter, gave the best Sharpe ratio, before looking further at whether using an RSI filter with our moving average crossover was

beneficial or not. Then we will compare the strategies to the Sharpe ratio results from the buy and hold strategy, and finally look at which SMA strategies overall gave the best Sharpe ratio.

Sharpe ratio	Spot	Q+1	Average	Ranking
No RSI	-6.8529	-0.4073	-3.6301	4
RSI 50/50	7.9872	3.3225	5.6548	3
RSI 70/30	8.2125	3.1960	5.7043	2
RSI 80/20	8.7556	3.6231	6.1893	1
Average	4.5256	2.4336		
Ranking	1	2		

Table 12: Sharpe ratio for simple moving average strategies

From the table 11 we can see that analyzing the spot data gave an overall higher Sharpe, and by a large amount. The average Sharpe ratio from the all the strategies with/without the RSI filters came in at 4.5256, while analyzing the quarter data only gave an average Sharpe of 2.4336.

Further from this table we can see that using an RSI filter was beneficial, as all of them managed to obtain a higher Sharpe than using no RSI. This has been consistent when looking at the returns in isolation, the risk in isolation and now the Sharpe ratio, so it makes sense.

The RSI filter that gave the best average Sharpe ratio was the RSI 80/20 filter with an average Sharpe of 6.1893, with the RSI 70/30 filter second with 5.7043 and the RSI 50/50 filter very close behind at 5.6548. Using no RSI gave an average Sharpe of -3.6301, which is the only one negative. And so, using an RSI filter is clearly beneficial when measuring performance.

No RSI Sharpe					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**1**
SMA(5)>SMA(20)	3.4054	0.0439	1.4827	1.644	**3**
SMA(1)>SMA(10)	-7.8336	-20.3554	-16.5436	-14.9109	**6**
SMA(1)>SMA(20)	-7.4813	-12.3067	-16.6988	-12.1623	**5**
SMA(2)>SMA(10)	-10.7872	-16.5612	-6.7096	-11.3527	**4**
SMA(5)>SMA(10)	3.3456	2.8689	1.3368	2.5171	**2**
Average	-3.8702	-9.2621	-7.4265	-6.8529	
No RSI Sharpe					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**1**
SMA(5)>SMA(20)	7.6044	0.0809	5.9602	4.5485	**3**

SMA(1)>SMA(10)	-0.7053	-9.4002	-3.9184	-4.6746	**5**
SMA(1)>SMA(20)	11.1409	0.252	3.271	4.888	**2**
SMA(2)>SMA(10)	0.1864	-1.4366	4.014	0.9212	**4**
SMA(5)>SMA(10)	-5.5377	-6.2396	-11.3809	-7.7194	**6**
Average	2.5377	-3.3487	-0.4108	-0.4073	

RSI 50/50 Sharpe					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (spot)	Ranking
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**5**
SMA(5)>SMA(20)	8.8291	15.7883	-0.5474	8.0233	**3**
SMA(1)>SMA(10)	22.8103	-4.1257	-11.9903	2.2315	**6**
SMA(1)>SMA(20)	10.0042	17.6517	-3.6683	7.9959	**4**
SMA(2)>SMA(10)	18.6306	21.4071	-1.3114	12.9088	**1**
SMA(5)>SMA(10)	-15.6087	26.9975	14.9407	8.7765	**2**
Average	**8.9331**	**15.5438**	**-0.5153**	**7.9872**	
RSI 50/50 Sharpe					
Quarter signal	**NBP**	**NCG**	**TTF**	Average across all hubs Signal (Q+1)	Ranking
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**3**
SMA(5)>SMA(20)	13.3845	6.1115	4.9688	8.1549	**2**
SMA(1)>SMA(10)	2.1480	-14.2530	-11.5951	-7.9001	**5**
SMA(1)>SMA(20)	-13.9634	-13.1463	-14.4694	-13.8597	**6**
SMA(2)>SMA(10)	30.5207	-12.7479	-6.8408	3.6440	**4**
SMA(5)>SMA(10)	23.1281	27.6268	28.9648	26.5732	**1**
Average	**11.0436**	**-1.2818**	**0.2057**	**3.3225**	

RSI 70/30 Sharpe					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**5**
SMA(5)>SMA(20)	8.8291	17.7544	1.2172	9.2669	**2**
SMA(1)>SMA(10)	24.9338	-2.7224	-10.9867	3.7416	**6**
SMA(1)>SMA(20)	10.0042	17.6517	-3.6683	7.9959	**3**
SMA(2)>SMA(10)	22.5938	15.9588	-1.3114	12.4137	**1**
SMA(5)>SMA(10)	-15.9914	26.0737	12.8512	7.6445	**4**
Average	**10.0739**	**14.9432**	**-0.3796**	**8.2125**	
RSI 70/30 Sharpe					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**3**
SMA(5)>SMA(20)	13.3845	5.6754	5.0014	8.0204	**2**
SMA(1)>SMA(10)	2.1480	-11.0346	-10.7130	-6.5332	**5**
SMA(1)>SMA(20)	-13.9634	-10.0075	-12.6957	-12.2222	**6**
SMA(2)>SMA(10)	30.5207	-12.7479	-6.8408	3.6440	**4**
SMA(5)>SMA(10)	22.3238	27.6268	19.2626	23.0711	**1**
Average	**10.8827**	**-0.0976**	**-1.1971**	**3.1960**	

RSI 80/20 Sharpe					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**5**
SMA(5)>SMA(20)	8.8291	17.7544	1.2172	9.2669	**2**
SMA(1)>SMA(10)	24.9338	-2.7224	-10.9867	3.7416	**6**
SMA(1)>SMA(20)	10.0042	17.6517	-3.6683	7.9959	**4**
SMA(2)>SMA(10)	22.5938	21.4071	-1.3114	14.2298	**1**
SMA(5)>SMA(10)	-12.6491	26.0737	12.2065	8.5437	**3**
Average	**10.7424**	**16.0329**	**-0.5086**	**8.7556**	
RSI 80/20 Sharpe					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**3**
SMA(5)>SMA(20)	13.3845	5.6754	5.0014	8.0204	**2**
SMA(1)>SMA(10)	2.1480	-14.2530	-11.5951	-7.9001	**5**
SMA(1)>SMA(20)	-13.9634	-10.0075	-12.6957	-12.2222	**6**
SMA(2)>SMA(10)	30.5207	-12.7479	-6.8408	3.6440	**4**
SMA(5)>SMA(10)	23.1281	27.6268	28.9648	26.5732	**1**
Average	**11.0436**	**-0.7413**	**0.5669**	**3.6231**	

Table 13: Sharpe ratio for simple moving average strategies

Looking at the performance measure from our strategies without RSI, they all get beaten by the buy and hold strategy. Generally, the results from the strategies without RSI come in bad if we compare them to the buy and hold's Sharpe ratio of 7.4553. Utilizing the spot signals 3/5 of the strategies are negative, one up to -14.9, and analyzing the quarter data gives a little bit better results, but 2/5 are still negative. The strategy that comes closest to the buy and hold is the SMA(1)>SMA(20) strategy analyzing the quarter data.

If we look at the results obtained with the RSI filter, they are a lot better. Using the 50/50 filter and analyzing the spot data, 4/5 of the SMA strategies outperform the buy and hold strategy and all the Sharpe ratios are positive. Analyzing the quarter data, the results are worse, with only 2/5 of the strategies managing to outperform the buy and hold. Here the results are more inconsistent – the SMA(5)>SMA(10) has an average high Sharpe at 26.5732, while the SMA(1)>SMA(20) strategy has a negative one at -13.8597.

The RSI 70/30 and RSI 80/20 results are quite similar with 4/5 of the SMA strategies outperforming the buy and hold utilizing the spot signals, and only 2/5 manage to outperform buy and hold analyzing the quarter signals. In general, across the RSI filters we see that the Sharpe ratio obtained from the spot data is good and more consistent, while the quarter signals

give more inconsistency and some very high and very low Sharpe ratios. We will now take a deeper look at each of the SMA strategies.

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI 80/20**			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
(5)>(20)	1.644	4.5485	8.0233	**8.1549**	9.2669	8.0204	9.2669	8.0204	7.1182	**2**
(1)>(10)	-14.9109	-4.6746	2.2315	-7.9001	3.7416	-6.5332	3.7416	-7.9001	-4.0255	**5**
(1)>(20)	-12.1623	4.888	7.9959	-13.8597	7.9959	-12.2222	7.9959	-12.2222	-2.6989	**4**
(2)>(10)	-11.3527	0.9212	12.9088	3.6440	12.4137	3.6440	14.2298	3.6440	5.0066	**3**
(5)>(10)	2.5171	-7.7194	8.7765	**26.5732**	7.6445	23.0711	8.5437	26.5732	11.9975	**1**

Table 14: Sharpe ratio for simple moving average strategies

As the SMA(5)>SMA(10) overall had the highest returns and the lowest standard deviation, it's no surprise that it has the highest Sharpe ratio as well. 3/5 of the SMA strategies come in overall positive, while the SMA(1)>(10) and the SMA (1)>(20) strategy give a negative Sharpe.

Looking at the results from our Sharpe ratios we have found that analyzing the spot signals gave overall better results and fit our strategies better. The RSI strategies as usual get more weight though, if we look at the table, we can see that if using no RSI, the quarter signals are preferable, but both give a negative Sharpe.

Further, we have looked at whether using an RSI filter was beneficial, and it was no surprise that it was. For the SMA strategies the RSI filters gave both a better return and a better risk measure, so it's only logical that the Sharpe ratio came in better with the RSI filters as well.

When we compared our results to a buy and hold strategy, none of the strategies using no RSI managed to outperform a buy and hold strategy. Using RSI, some of our strategies did. Using the 50/50 filter and analyzing the spot, 4/5 of the SMA strategies outperformed the buy and hold, while only 2/5 managed to do so with the quarter signals. With the RSI 70/30 and the RSI 80/20 the results came in quite similar and here 4/5 of the strategies outperformed the buy and hold analyzing the spot signals, and 2/5 when analyzing the quarter signals.

EMA/SMA strategies

Now that we've looked at the simple moving average strategies (SMA), we will continue and look at the strategies we have tested where we have incorporated one exponential moving average(EMA) and one SMA. In these strategies we use the exponential moving average as the short-term moving average and keep the simple moving average as the long one. The exponential moving average puts more weight on the price action from the recent days, and so it should react faster to changes in trend. We will look at the results first, before looking at risk and further a performance measure before we sum up our findings.

Returns

We will start by looking at which dataset fit our EMA/SMA strategies better, before moving on to see whether using an RSI filter was beneficial or not.

Returns	**Spot**	**Q+1**	**Average**	Ranking
No RSI	0.1766	0.2170	0.1968	**1**
RSI 50/50	0.3331	0.0298	0.1815	**2**
RSI 70/30	0.2800	0.0068	0.1434	**4**
RSI 80/20	0.3139	0.0298	0.1719	**3**
Average	0.2759	0.0709		
Ranking	**1**	**2**		

Table 15: Hybrid strategy returns

When it comes to the EMA/SMA strategies, we can see that the spot signals on average give superior returns compared to the quarter signals. Analyzing the spot data provides on average a return of 0.2759 which outperforms the average returns from quarter data, which provide returns of 0.0709. Looking at the table though we can see that using no RSI, the quarter signals give the best return, and for the RSI strategies the spot data gives the best return.

From the same table we can see how the RSI filter affected the returns. All of the returns were positive, and the averages range from 0.1434-0.1968. With the EMA/SMA strategies, using no RSI filter actually gave the best returns, which is different from the SMA strategies where using no RSI gave the worst returns. We can see a pattern from the table – using no RSI gave the best returns, using the RSI filter which filters out the least gave the 2nd biggest returns, and the RSI filter that filters out the most trades has the worst return. We will now check how our results compare to a buy and hold strategy.

No RSI returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**2**
EMA(5)>SMA(20)	0.2377	0.1268	0.1322	0.1656	**3**
EMA(5)>SMA(30)	0.4868	0.1032	0.2098	0.2666	**1**
EMA(5)>SMA(5)	0.0977	0.1100	0.0856	0.0978	**4**
Average	**0.2741**	**0.1133**	**0.1425**	**0.1766**	
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**2**
EMA(5)>SMA(20)	0.1323	0.0793	0.1581	0.1232	**3**
EMA(5)>SMA(30)	0.5252	0.5681	0.5216	0.5383	**1**
EMA(5)>SMA(5)	0.0690	-0.0826	-0.0180	-0.0105	**4**
Average	**0.2422**	**0.1883**	**0.2206**	**0.2170**	

RSI 50/50 Returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**4**
EMA(5)>SMA(20)	0.1088	0.4136	0.1351	0.2192	**3**
EMA(5)>SMA(30)	0.4690	0.3225	0.4063	0.3993	**1**
EMA(5)>SMA(5)	0.5460	0.3017	0.2949	0.3809	**2**
Average	**0.3746**	**0.345933**	**0.278767**	**0.3331**	
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**1**
EMA(5)>SMA(20)	0.0683	-0.0260	-0.0350	0.0024	**4**
EMA(5)>SMA(30)	0.0501	-0.0419	0.1432	0.0505	**2**
EMA(5)>SMA(5)	0.1031	-0.1214	0.1282	0.0366	**3**
Average	**0.073833**	**-0.0631**	**0.078807**	**0.0298**	

RSI 70/30 Returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**

Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**4**
EMA(5)>SMA(20)	0.1589	0.4136	0.1856	0.2527	**3**
EMA(5)>SMA(30)	0.4690	0.1296	0.1946	0.2644	**2**
EMA(5)>SMA(5)	0.5461	0.1274	0.2949	0.3228	**1**
Average	**0.3913**	**0.2235**	**0.2250**	**0.2800**	
RSI 70/30 Std					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**1**
EMA(5)>SMA(20)	0.0683	-0.0260	-0.0350	0.0024	**3**
EMA(5)>SMA(30)	0.0501	-0.0419	-0.0645	-0.0188	**4**
EMA(5)>SMA(5)	0.1031	-0.1214	0.1282	0.0366	**2**
Average	**0.0738**	**-0.0631**	**0.0096**	**0.0068**	

RSI 80/20 Returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**4**
EMA(5)>SMA(20)	0.1589	0.4136	0.1351	0.2359	**3**
EMA(5)>SMA(30)	0.4690	0.3225	0.4063	0.3992	**1**
EMA(5)>SMA(5)	0.5461	0.0785	0.2949	0.3065	**2**
Average	**0.3913**	**0.2715**	**0.2788**	**0.3139**	
RSI 80/20 Std					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**1**
EMA(5)>SMA(20)	0.0683	-0.0260	-0.0350	0.0024	**4**
EMA(5)>SMA(30)	0.0501	-0.0419	0.1432	0.0504	**2**
EMA(5)>SMA(5)	0.1031	-0.1214	0.1282	0.0366	**3**
Average	**0.0738**	**-0.0631**	**0.0788**	**0.0298**	

Table 16: Hybrid strategy returns

The no-RSI returns come in quite good, consistently positive across all the hubs analyzing the spot data and only a few negative tests from the EMA(5)>SMA(5) strategy analyzing the quarter data. If we compare these results to a buy and hold, we can see that even though the average returns are mostly positive, only 1/3 of the EMA/SMA strategies managed to outperform the buy and hold return on both the datasets.

For the EMA/SMA strategies with the RSI 50/50 filter, the results analyzing the spot data performed well, as all three EMA/SMA strategies managed to outperform the buy and hold strategy. When it comes to the quarter signals however, they were significantly worse. Here the average returns are barely positive ranging from 0.0024-0.0505, and all of them performing worse than the buy and hold strategy.

When we applied the 70/30 filter and the 80/20 filter, we get similar results. Analyzing the spot data, 3/3 of the strategies outperform the buy and hold, while analyzing the quarter data none of them manage to do so. For the RSI strategies, analyzing the spot data was very beneficial. We will now look at which of the EMA/SMA strategies gave the best returns across the different hubs and with/without the RSI filters.

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI 80/20**			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
B&H									0.1719	2
(5)>(20)	0.1656	0.1232	0.2192	0.0024	0.2527	0.0024	0.2359	0.0024	0.1255	4
(5)>(30)	0.2666	0.5383	0.3993	0.0505	0.2644	-0.0188	0.3992	0.0504	0.2437	1
(5)>(5)	0.0978	-0.0105	0.3809	0.0366	0.3228	0.0366	0.3065	0.0366	0.1509	3

Table 17: Hybrid strategy returns

As we can see from the table above, the EMA(5)>SMA(30) strategy has the highest average return at 0.2437. This is also the only strategy that in average manages to outperform the buy and hold strategy. From this table we can also see that the EMA(5)>SMA(20) strategy gives the least return, but still positive. We have also found that the strategies without RSI filter performs best analyzing quarter data, while the RSI strategies perform far better analyzing the spot data.

When it comes to the different RSI filters, using no RSI gave the best return here. And we can see from the results that the more trades got filtered out with these strategies, the worse the returns were, with the RSI 70/30 filtering out the most trades giving the least average return.

When we compared the returns obtained to the buy and hold strategy, we found that even though no RSI had the highest average return, only 1/3rd of the results managed to outperform the buy and hold strategy. When we applied the RSI filters, all of them managed to outperform the buy and hold strategy analyzing spot data, while if we utilized the quarter signals none of the strategies outperformed the buy and hold.

And in average the EMA(5)>SMA(30) was the best performing strategy across the different hubs with the different RSI filters.

Risk measure

Now that we have looked at the returns of the EMA/SMA strategies we will continue by looking at the risk measures. We will first look at which datasets gave the best risk with our strategies, then we will see how using RSI filters affected the risk, and finally we will look at how our strategies' standard deviation compares to the buy and hold strategy.

St.dev	Spot	Q+1	Average	Ranking
No RSI	0.0186	0.0205	0.0196	1
RSI 50/50	0.0186	0.0212	0.0199	2
RSI 70/30	0.0191	0.0216	0.0203	4
RSI 80/20	0.0187	0.0212	0.0199	3
Average	0.0187	0.0211		
Ranking	1	2		

Table 18: Standard deviation results for the hybrid strategies

As we can see from table 17, from all our methods tested with/without RSI and across the different hubs analyzing the spot data resulted in the lowest risk with 0.0187 and analyzing the quarter data gave a higher risk at 0.0211. Both with and without RSI, the spot signal provided the lowest risk.

Further from the table we can see how an RSI filter affected our risk. We see the same pattern here as with the returns – the more trades that got filtered out from the RSI, the higher the risk was. Using no RSI gave the best and lowest risk measure, with the RSI 50/50 having the 2nd lowest standard deviation, the RSI 80/20 filter came in 3rd and finally the RSI 70/30 filter which filters out the most trades had the highest risk.

No RSI Std					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
EMA(5)>SMA(20)	0.022	0.0198	0.0205	0.0208	**4**
EMA(5)>SMA(30)	0.0185	0.0166	0.0168	0.0173	**1**
EMA(5)>SMA(5)	0.0153	0.0192	0.0188	0.0178	**2**
Average	**0.0186**	**0.0186**	**0.0187**	**0.0186**	
No RSI Std					

Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**2**
EMA(5)>SMA(20)	0.0193	0.0199	0.0187	0.0193	**1**
EMA(5)>SMA(30)	0.0208	0.0209	0.0213	0.0210	**3**
EMA(5)>SMA(5)	0.0214	0.0216	0.0211	0.0213	**4**
Average	**0.0205**	**0.0208**	**0.0203**	**0.0205**	

RSI 50/50 Std					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (spot)	Ranking
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
EMA(5)>SMA(20)	0.0220	0.0169	0.0182	0.0190	**3**
EMA(5)>SMA(30)	0.0203	0.0171	0.0192	0.0188	**2**
EMA(5)>SMA(5)	0.0167	0.0191	0.0182	0.0180	**1**
Average	**0.0196**	**0.0177**	**0.0185**	**0.0186**	
RSI 50/50 Std					
Quarter signal	**NBP**	**NCG**	**TTF**	Average across all hubs Signal (Q+1)	Ranking
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
EMA(5)>SMA(20)	0.0186	0.0180	0.0182	0.0183	**1**
EMA(5)>SMA(30)	0.0200	0.0193	0.0180	0.0191	**2**
EMA(5)>SMA(5)	0.0294	0.0238	0.0257	0.0263	**4**
Average	**0.0227**	**0.0204**	**0.0206**	**0.0212**	

RSI 70/30 Std					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
EMA(5)>SMA(20)	0.0221	0.0169	0.0184	0.0192	**2**
EMA(5)>SMA(30)	0.0203	0.0195	0.0207	0.0202	**3**
EMA(5)>SMA(5)	0.0167	0.0189	0.0182	0.0179	**1**
Average	**0.0197**	**0.0185**	**0.0191**	**0.0191**	
RSI 70/30 Std					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**2**
EMA(5)>SMA(20)	0.0186	0.0180	0.0182	0.0183	**1**
EMA(5)>SMA(30)	0.0200	0.0193	0.0214	0.0202	**3**

EMA(5)>SMA(5)	0.0294	0.0238	0.0257	0.0263	**4**
Average	**0.0227**	**0.0204**	**0.0217**	**0.0216**	

RSI 80/20 Std					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**4**
EMA(5)>SMA(20)	0.0221	0.0169	0.0182	0.0191	**3**
EMA(5)>SMA(30)	0.0203	0.0171	0.0192	0.0188	**2**
EMA(5)>SMA(5)	0.0167	0.0193	0.0182	0.0181	**1**
Average	**0.0197**	**0.0178**	**0.0185**	**0.0187**	
RSI 80/20 Std					
Quarter signal	**Average across all hubs**				
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
EMA(5)>SMA(20)	0.0186	0.0180	0.0182	0.0183	**1**
EMA(5)>SMA(30)	0.0200	0.0193	0.0180	0.0191	**2**
EMA(5)>SMA(5)	0.0294	0.0238	0.0257	0.0263	**4**
Average	**0.0227**	**0.0204**	**0.0206**	**0.0212**	

Table 19: Standard deviation results for the hybrid strategies

We will now look at how our strategies compare to the buy and hold risk and will start with the strategies without RSI. Analyzing the spot signals 2/3 of the strategies had a lower risk than the buy and hold. The EMA(5)>SMA(30) strategy has an average standard deviation across all hubs of 0.0173, and the EMA(5)>SMA(5) has an average of 0.0178 which is good compared to the buy and hold's standard deviation of 0.0200. The EMA(5)>SMA(20) strategy has slightly higher standard deviation at 0.0208. On average these strategies outperform the buy and hold.

Analyzing the quarter data however, the results are worse. Here only one strategy manages to outperform the buy and hold, and that is the EMA(5)>SMA(20) strategy with a standard deviation of 0.0193. The two other strategies have a higher standard deviation than the buy and hold.

When we applied the RSI 50/50 filter, the results from the spot signals are great, as all three of the strategies manage to deliver a lower risk than the buy and hold strategy. With the quarter signals, 2/3 of the strategies managed to deliver a lower risk. The EMA(5)>SMA(5) strategy has a high standard deviation of 0.0263 and drags up the average.

The RSI 80/20 filter had similar results to the RSI 50/50 with 3/3 strategies outperforming the buy and hold when analyzing the spot data, and 2/3 of the strategies analyzing the quarter data having a lower risk.

Utilizing the RSI 70/30 filter 3/3 of the strategies outperformed the buy and hold when using the spot signals, but here only 1/3 of the strategies managed to outperform it analyzing the quarter data.

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI 80/20**			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
(5)>(20)	0.0208	0.0193	0.0190	0.0183	0.0192	0.0183	0.0191	0.0183	0.0190	**1**
(5)>(30)	0.0173	0.0210	0.0188	0.0191	0.0202	0.0202	0.0188	0.0191	0.0193	**2**
(5)>(5)	0.0178	0.0213	0.0180	0.0263	0.0179	0.0263	0.0181	0.0263	0.0215	**3**

Table 20: Standard deviation results for the hybrid strategies

We will now look at which of the EMA/SMA strategies delivered the lowest risk. We can see from the table above that the winning strategy was the EMA(5)>SMA(20) strategy which has an average standard deviation analyzing both datasets and across all hubs of 0.0190. The EMA(5)>SMA(30) strategy follows closely with an average standard deviation of 0.0193, while the EMA(5)>SMA(5) strategy has the highest standard deviation of 0.0215.

Analyzing the risk results from our EMA/SMA strategies we have found that both with and without RSI, utilizing the spot signals is the most beneficial for our strategies. Here we obtained a lower risk than on the tests we did with the quarter signals.

Further we have found that using no RSI delivered the lowest standard deviation, with the RSI 50/50 on 2nd place, RSI 80/20 on 3rd place and the RSI filter that filters out the most trades, 70/30, has the highest risk.

Comparing our results to the buy and hold strategy, we found using no RSI and analyzing the spot signals that 2/3 of the EMA/SMA strategies had a lower risk than buy and hold. Analyzing the quarter data, only one strategy managed to outperform the buy and hold benchmark, and that is the EMA(5)>SMA(20) strategy. We also found that this is the strategy that overall had the lowest risk with/without RSI, on the two datasets and across the different hubs.

With the RSI 50/50 filter, the results from the spot signals were great with 3/3 of the strategies delivering a better risk measure than the buy and hold. Utilizing the quarter signals, only 2/3

of the strategies managed to do so. The EMA(5)>SMA(5) was the one that did not outperform the buy and hold, and it had a high standard deviation dragging up the average of the RSI 50/50 tests.

The RSI 80/20 had similar results to the RSI 50/50 filter and using the RSI 70/30 filter, we found that 3/3 of the strategies outperformed the buy and hold when using the spot signals, and only 1/3 of the strategies managed to do so analyzing the quarter data.

Performance measure

Now that we've looked at results and risk in isolation for the EMA/SMA strategies, we will look at the Sharpe ratio, which is a performance measure that measures how good the return is compared to the risk taken.

Sharpe ratio	Spot	Q+1	Average	Ranking
No RSI	8.2369	9.4297	8.8333	1
RSI 50/50	17.0684	0.2240	8.6462	2
RSI 70/30	13.9609	-0.9719	6.4945	4
RSI 80/20	16.0149	0.2240	8.1195	3
Average	13.8203	2.2265		
Ranking	1	2		

Table 21: Sharpe ratio for the hybrid strategies

We will first look at which signals, spot or quarter gives the best performance measure, then we will look at whether using RSI was beneficial or not for these strategies.

From the table above we can see that overall, utilizing the spot signals give a much better Sharpe ratio than using the quarter signals. Using no RSI, the quarter signals actually give a slightly better Sharpe, but if we use the RSI filters the spot signals are much better.

Further we can see that using no RSI gave the overall highest average Sharpe with a measure of 8.8333. The RSI 50/50 filter is close behind though at 8.6462, with the RSI 80/20 in 3rd place and RSI 70/30 last. We can again see the pattern that the more trades get filtered out, the worse result we get.

No RSI Sharpe					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**2**

EMA(5)>SMA(20)	9.7885	5.2481	5.3379	6.7915	**3**
EMA(5)>SMA(30)	25.0450	4.8376	11.1215	13.6681	**1**
EMA(5)>SMA(5)	4.8796	4.5406	3.3334	4.2512	**4**
Average	**13.2377**	**4.8754**	**6.5976**	**8.2369**	
No RSI Sharpe					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**2**
EMA(5)>SMA(20)	5.6685	2.8421	7.2447	5.2518	**3**
EMA(5)>SMA(30)	24.1733	26.1276	23.4697	24.5902	**1**
EMA(5)>SMA(5)	2.1617	-4.8880	-1.9318	-1.5527	**4**
Average	**10.6678**	**8.0272**	**9.5942**	**9.4297**	

RSI 50/50 Sharpe					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (spot)	Ranking
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**4**
EMA(5)>SMA(20)	3.9187	23.0770	6.1624	11.0527	**3**
EMA(5)>SMA(30)	21.9990	17.5553	20.0238	19.8594	**2**
EMA(5)>SMA(5)	31.3302	14.6114	14.9378	20.2931	**1**
Average	**19.0826**	**18.4146**	**13.7080**	**17.0684**	
RSI 50/50 Sharpe					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (Q+1)	Ranking
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**1**
EMA(5)>SMA(20)	2.4392	-2.7153	-3.1825	-1.1529	**4**
EMA(5)>SMA(30)	1.3689	-3.3612	6.6801	1.5626	**2**
EMA(5)>SMA(5)	2.7273	-6.0463	4.1062	0.2624	**3**
Average	**2.1785**	**-4.0409**	**2.5346**	**0.2240**	

RSI 70/30 Sharpe					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**4**
EMA(5)>SMA(20)	6.1601	23.0770	8.8254	12.6875	**2**
EMA(5)>SMA(30)	21.9990	5.4652	8.3198	11.9280	**3**
EMA(5)>SMA(5)	31.3302	5.5336	14.9378	17.2672	**1**
Average	**19.8298**	**11.3586**	**10.6943**	**13.9609**	
RSI 70/30 Sharpe					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**1**
EMA(5)>SMA(20)	2.4392	-2.7153	-3.1825	-1.1529	**3**

EMA(5)>SMA(30)	1.3689	-3.3612	-4.0835	-2.0252	**4**
EMA(5)>SMA(5)	2.7273	-6.0463	4.1062	0.2624	**2**
Average	**2.1785**	**-4.0409**	**-1.0532**	**-0.9719**	

RSI 80/20 Sharpe					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**4**
EMA(5)>SMA(20)	6.1601	23.0770	6.1624	11.7998	**3**
EMA(5)>SMA(30)	21.9990	17.5553	20.0238	19.8594	**1**
EMA(5)>SMA(5)	31.3302	2.8886	14.9378	16.3855	**2**
Average	**19.8298**	**14.5070**	**13.7080**	**16.0149**	
RSI 80/20 Sharpe					
Quarter signal	**Average across all hubs**				
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**1**
EMA(5)>SMA(20)	2.4392	-2.7153	-3.1825	-1.1529	**4**
EMA(5)>SMA(30)	1.3689	-3.3612	6.6801	1.5626	**2**
EMA(5)>SMA(5)	2.7273	-6.0463	4.1062	0.2624	**3**
Average	**2.1785**	**-4.0409**	**2.5346**	**0.2240**	

Table 22: Sharpe ratio for the hybrid strategies

We will now look at how our strategies' Sharpe ratio compare to the buy and hold strategy across all hubs.

Using no RSI, only 1/3 of the EMA/SMA strategies manages to outperform the buy and hold. This is both when analyzing the spot data and when analyzing the quarter data, and the only strategy that manages to do so is the EMA(5)>SMA(30) strategy.

Using RSI filters, the results are similar across all of them. Using the spot signals, all of the EMA/SMA strategies manages to beat the buy and hold, while when using the quarter signals none of them manage to do so. Using the spot signals seems to significantly improve the performance of the strategies with RSI filters.

	No RSI		**RSI 50/50**		**RSI 70/30**		**RSI 80/20**			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank

(5)>(20)	6.7915	5.2518	11.0527	**-1.1529**	12.6875	-1.1529	11.7998	-1.1529	5.5156	**3**
(5)>(30)	13.6681	24.5902	19.8594	1.5626	11.9280	-2.0252	19.8594	1.5626	11.3756	**1**
(5)>(5)	4.2512	-1.5527	20.2931	0.2624	17.2672	0.2624	16.3855	0.2624	7.1789	**2**

Table 23: Sharpe ratio for the hybrid strategies

We will now look at which of the EMA/SMA strategies gave the best Sharpe measure. Overall, the EMA(5)>SMA(30) strategy gave the best one, with the EMA(5)>SMA(5) second while the EMA(5)>SMA(20) has the lowest Sharpe.

From our look into the EMA/SMA strategies we found that the quarter signals fit the strategies without RSI slightly better than the spot signals, but for the strategies with RSI the spot signals were significantly better. When it comes to using RSI we found that using no RSI gave the best Sharpe ratio, and the more trades were filtered out, the worse Sharpe ratio we got. When we compared our results to the buy and hold strategy, we found that when using no RSI, 1/3 of the strategies gave a better Sharpe measure than the buy and hold strategy both when analyzing the quarter and the spot data. And when we used RSI filters, we found that all of our strategies managed to give a better Sharpe than the buy and hold when we analyzed the spot data. But when we analyzed the quarter data, none of the RSI strategies managed to do so. Analyzing the spot data is clearly beneficial for the strategies with RSI.

And finally we found that in terms of each individual EMA/SMA strategy, the EMA(5)>SMA(30) gave the highest average Sharpe ratio. We will now move forward and look at the EMA/EMA strategies

EMA/EMA strategies

Now that we've looked into using one exponential and one simple moving average, we will continue and look at the strategies we have tested where we used two exponential moving averages. Again, one short and one long. Here, both moving averages react faster to the recent changes in price. This could lead to more precise entry/exit signals for example, but it could also lead to entering/exiting trades too early. We will first start by looking at our returns in isolation, then we will look at the risk before finally looking into these two in conjunction with the help of a performance measure.

Returns

We will start by looking at which of the datasets fit our EMA/EMA strategies better, then we will check if using RSI was beneficial or not for these strategies before moving on to the comparison between these returns and the ones from the buy and hold strategies. Finally, we will look into which of the EMA/EMA strategies gave the best return.

Returns	**Spot**	**Q+1**	**Average**	Ranking
No RSI	0.3347	0.2040	0.2694	**4**
RSI 50/50	0.3092	0.3652	0.3372	**2**
RSI 70/30	0.2933	0.3341	0.3137	**3**
RSI 80/20	0.3158	0.3652	0.3405	**1**
Average	0.3133	0.3171		
Ranking	**2**	**1**		

Table 24: Exponential moving average returns

From the table above we can see that the EMA/EMA strategies perform similarly on both datasets. Utilizing the spot signals the average return from our two EMA/EMA strategies, with and without RSI filter and across all hubs, was 0.3133. Utilizing the quarter signals the average return was 0.3171, so the quarter signals give a slightly better return.

Without RSI, the dataset that gave best return was the spot data, and with RSI we can see that the quarter data performed better.

Looking at the table we can further see that using RSI was beneficial for the EMA/EMA strategies. The RSI 80/20 performed the best with an average return of 0.3405 with both strategies and across all hubs, with RSI 50/50 in second, RSI 70/30 3rd and no RSI last. All of the average results are positive and perform well ranging from 0.2694-0.3405.

No RSI returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**3**
EMA(5)>EMA(20)	0.0994	0.5187	0.3907	0.3363	**1**
EMA(5)>EMA(30)	0.4838	0.2293	0.1322	0.2818	**2**
Average	**0.2916**	**0.3740**	**0.2615**	**0.3090**	
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**2**
EMA(5)>EMA(20)	0.3461	0.1844	0.2047	0.2451	**1**

EMA(5)>EMA(30)	0.1323	0.1743	0.1823	0.1630	**3**
Average	0.2392	0.1794	0.1935	0.2040	

RSI 50/50 Returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**3**
EMA(5)>EMA(20)	0.1088	0.4136	0.1351	0.2192	**2**
EMA(5)>EMA(30)	0.4690	0.3225	0.4063	0.3992	**1**
Average	**0.2889**	**0.3680**	**0.2707**	**0.3092**	
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**2**
EMA(5)>EMA(20)	0.5839	0.5245	0.5760	0.5614	**1**
EMA(5)>EMA(30)	0.1370	0.1988	0.1710	0.1690	**3**
Average	**0.3604**	**0.3617**	**0.3735**	**0.3652**	

RSI 70/30 Returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**3**
EMA(5)>EMA(20)	0.1404	0.6083	0.2180	0.3222	**1**
EMA(5)>EMA(30)	0.4690	0.1296	0.1946	0.2644	**2**
Average	**0.3047**	**0.3690**	**0.2063**	**0.2933**	
RSI 70/30 Std					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**2**
EMA(5)>EMA(20)	0.5839	0.4450	0.4764	0.5017	**1**
EMA(5)>EMA(30)	0.1410	0.2005	0.1578	0.1664	**3**
Average	**0.3624**	**0.3227**	**0.3171**	**0.3341**	

RSI 80/20 Returns					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**3**
EMA(5)>EMA(20)	0.1918	0.6765	0.2670	0.3784	**1**
EMA(5)>EMA(30)	0.4351	0.1609	0.1635	0.2532	**2**
Average	**0.3134**	**0.4187**	**0.2153**	**0.3158**	
RSI 80/20 Std					

Quarter signal	NBP	NCG	TTF	Average across all hubs	
				Signal (Q+1)	Ranking
Buy and hold	0.1480	0.1793	0.1882	**0.1719**	**2**
EMA(5)>EMA(20)	0.5839	0.5245	0.5760	0.5614	**1**
EMA(5)>EMA(30)	0.1370	0.1988	0.1710	0.1690	**3**
Average	**0.3604**	**0.3617**	**0.3735**	**0.3652**	

Table 25: Exponential moving average returns

We will now look at how the return from the EMA/EMA strategies compare to the buy and hold strategy. Using no RSI and analyzing the spot data, both strategies were able to outperform the buy and hold. Analyzing the quarter data, the EMA(5)>EMA(20) made a return of 0.2451 and outperformed the buy and hold, while the EMA(5)>EMA(30) did not, but came close at 0.1630 vs 0.1719 from buy and hold.

Analyzing the spot data and using the RSI 50/50 filter both of the strategies managed to outperform the buy and hold. Analyzing the quarter data the EMA(5)>EMA(20) gave a return of 0.5614 and outperformed the buy and hold by a larger margin, while the EMA(5)>EMA(30) still didn't beat the buy and hold but came closer at 0.1690 vs 0.1719.

The results are the same with the RSI 70/30 and RSI 80/20 filters, with both strategies outperform the buy and hold using the spot signals while only the EMA(5)>EMA(20) manages to do so using the quarter signals. Overall all of the EMA/EMA strategies were positive and most of them outperformed the buy and hold strategy.

We will now look at which of the two strategies gave the best return analyzing both datasets and with/without RSI.

	No RSI		RSI 50/50		RSI 70/30		RSI 80/20			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
Buy and hold									0.1719	3
EMA(5)>EMA(20)	0.3363	0.2451	0.2192	0.5614	0.3222	0.5017	0.3784	0.5614	0.3907	1
EMA(5)>EMA(30)	0.2818	0.1630	0.3992	0.1690	0.2644	0.1664	0.2532	0.1690	0.2332	2

Table 26: Exponential moving average returns

As we can see from the table above, the EMA(5)>EMA(20) strategy gave the best average return across all the hubs and with/without the RSI filters. This was no surprise after we compared our strategies to buy and hold.

To summarize, looking over our EMA/EMA strategies we found that the datasets gave on average a similar return with some differences. Using no RSI, analyzing the spot data gave a better return, and using RSI the quarter data performed better.

Further we found that using RSI was beneficial to increase the returns. We tested the EMA/EMA strategies with/without RSI filters, and found that on average, all the RSI filters gave a better return than using the signals only.

Comparing our results to the buy and hold, both EMA/EMA strategies managed to outperform the buy and hold analyzing the spot data. Analyzing the quarter data, only the EMA(5)>EMA(20) strategy managed to do so. With that said, the EMA(5)>EMA(30) came quite close to outperforming the buy and hold in some cases. Out of the two strategies, the EMA(5)>EMA(20) strategy gave on average the best return.

Risk measures

Now that we have looked at the returns, we will continue by looking at how the EMA/EMA strategies performed when it came to risk. We will first look into which signals gave the lowest risk, the quarter or spot signals, then we'll take a look at whether using RSI was beneficial or not to reduce the risk, before comparing the results we have to a buy and hold strategy. And finally, we'll look into which of the two strategies had the best risk measure.

St.dev	Spot	Q+1	Average	Ranking
No RSI	0.0181	0.0212	0.0197	1
RSI 50/50	0.0189	0.0212	0.0201	3
RSI 70/30	0.0192	0.0226	0.0209	4
RSI 80/20	0.0184	0.0212	0.0198	2
Average	0.0187	0.0216		
Ranking	1	2		

Table 27: Standard deviation results for the exponential moving average strategies

From the table above we can see that using the spot signals, the average standard deviation for both EMA/EMA strategies across all hubs and with/without RSI was 0.0187, and 0.0216 from the quarter signals. And so, using the spot signals gave the best risk measure – both with and without RSI.

When it comes to the question if using an RSI filter was beneficial or not, we can see from the table that in this case, it was not. Using no RSI, the average standard deviation with both

strategies and across all hubs was 0.0197. The results from the RSI 80/20 filter came very close at 0.0198 though which is slightly higher. The RSI 50/50 filter came in at 3rd place and the RSI 70/30 filter last.

No RSI Std					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
EMA(5)>EMA(20)	0.0155	0.0187	0.0181	0.0174	**1**
EMA(5)>EMA(30)	0.0216	0.0169	0.0179	0.0188	**2**
Average	**0.0186**	**0.0178**	**0.0180**	**0.0181**	
No RSI Std					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**2**
EMA(5)>EMA(20)	0.0233	0.0177	0.0187	0.0199	**1**
EMA(5)>EMA(30)	0.0187	0.0239	0.0251	0.0225	**3**
Average	**0.0210**	**0.0208**	**0.0219**	**0.0212**	

RSI 50/50 Std					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (spot)	Ranking
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
EMA(5)>EMA(20)	0.0220	0.0169	0.0182	0.0190	**2**
EMA(5)>EMA(30)	0.0203	0.0171	0.0192	0.0188	**1**
Average	**0.0211**	**0.0170**	**0.0187**	**0.0189**	
RSI 50/50 Std					
Quarter signal	**NBP**	**NCG**	**TTF**	Average across all hubs Signal (Q+1)	Ranking
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**1**
EMA(5)>EMA(20)	0.0227	0.0217	0.0226	0.0224	**3**
EMA(5)>EMA(30)	0.0166	0.0241	0.0195	0.0201	**2**
Average	**0.0197**	**0.0229**	**0.0211**	**0.0212**	

RSI 70/30 Std					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**2**
EMA(5)>EMA(20)	0.0193	0.0184	0.0170	0.0182	**1**
EMA(5)>EMA(30)	0.0203	0.0195	0.0207	0.0202	**3**
Average	**0.0198**	**0.0190**	**0.0188**	**0.0192**	

RSI 70/30 Std					
Quarter signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**1**
EMA(5)>EMA(20)	0.0227	0.0230	0.0237	0.0232	**3**
EMA(5)>EMA(30)	0.0166	0.0273	0.0223	0.0221	**2**
Average	**0.0197**	**0.0252**	**0.0230**	**0.0226**	

RSI 80/20 Std					
Spot signal				**Average across all hubs**	
	NBP	**NCG**	**TTF**	**Signal (spot)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**3**
EMA(5)>EMA(20)	0.0186	0.0173	0.0165	0.0175	**1**
EMA(5)>EMA(30)	0.0210	0.0192	0.0177	0.0193	**2**
Average	**0.0198**	**0.0183**	**0.0171**	**0.0184**	
RSI 80/20 Std					
Quarter signal	**Average across all hubs**				
	NBP	**NCG**	**TTF**	**Signal (Q+1)**	**Ranking**
Buy and hold	**0.0205**	**0.0195**	**0.0201**	**0.0200**	**1**
EMA(5)>EMA(20)	0.0227	0.0217	0.0226	0.0224	**3**
EMA(5)>EMA(30)	0.0166	0.0241	0.0195	0.0201	**2**
Average	**0.0197**	**0.0229**	**0.0211**	**0.0212**	

Table 28: Standard deviation results for the exponential moving average strategies

We will now investigate how our results compare to a buy and hold strategy. Using no RSI and analyzing the spot data, both EMA/EMA strategies delivered a lower risk than the buy and hold. Analyzing the quarter data, only the EMA(5)>EMA(20) managed to so, while the EMA(5)>EMA(30) had an average standard deviation of 0.0225.

Applying the RSI 50/50 filter and the 80/20 filter, the results were similar. Both of our strategies managed to deliver a lower risk than the buy and hold analyzing the spot data, but analyzing the quarter data, none of our strategies gave a better risk measure than the buy and hold.

With the RSI 70/30 filter, the results were different. Using the spot signals only the EMA(5)>EMA(20) strategy managed to beat the buy and hold and using the quarter signals none of our strategies managed to outperform it.

Further we will investigate which of our two strategies gave the best risk measure.

	No RSI		RSI 50/50		RSI 70/30		RSI 80/20			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
EMA(5)>EMA(20)	0.0174	0.0199	0.0190	0.0224	0.0182	0.0232	0.0175	0.0224	0.0200	**1**
EMA(5)>EMA(30)	0.0188	0.0225	0.0188	0.0201	0.0202	0.0221	0.0193	0.0201	0.0202	**2**

Table 29: Standard deviation results for the exponential moving average strategies

As we can see, the EMA(5)>EMA(20) strategy gave the best risk measure, but just slightly with an average standard deviation of 0.0200 vs 0.0202 from the EMA(5)>EMA(30) strategy.

By looking into our risk measures from the EMA/EMA strategies we have found that for the EMA/EMA strategies, analyzing the spot data gave the lowest risk. Further we found that using no RSI gave on average lower risk than using RSI, so using no RSI was best, with the RSI 80/20 filter following closely behind in 2nd place. When we compared our results to a buy and hold strategy, analyzing the spot signals most of the strategies across the different filters managed to outperform the buy and hold. Analyzing the quarter signals however, the risk from our strategies was often higher than the buy and hold. And finally, we found that out of the two strategies, the EMA(5)>EMA(20) gave on average a lower risk than the EMA(5)>EMA(30) strategy.

Performance measure

Now that we have looked at both risk and returns in isolation, we will look at them together using a Sharpe ratio. We will start by looking at which dataset gave the highest Sharpe, then we will look at whether using an RSI filter was beneficial or not, before we'll compare to a buy and hold strategy, and finally look into which of the EMA/EMA strategies gave the best performance measure.

Sharpe ratio	**Spot**	**Q+1**	**Average**	**Ranking**
No RSI	16.6602	8.5531	12.6067	4
RSI 50/50	15.45603	15.6637	15.5599	2
RSI 70/30	14.20463	13.63802	13.9213	3
RSI 80/20	16.04845	15.6637	15.8561	1
Average	15.5923	13.3796		
Ranking	1	2		

Table 30: Sharpe ratio for the exponential moving average strategies

From the table above we can see the average Sharpe ratio from both EMA/EMA strategies and across all hubs. When it comes to which of the datasets fit our strategies better, analyzing the spot data gave a higher Sharpe than when we analyzed the quarter data.

From the table we can also see that using an RSI filter was clearly beneficial for the performance measure, as all three of the different RSI filters gave better results than the ones we got using no filter. The RSI 80/20 filter gave the best Sharpe ratio with 15.8561, followed closely by the RSI 50/50 filter which had an average Sharpe ratio of 15.5599, then the RSI 70/30 filter came in 3rd place and no RSI last.

No RSI Sharpe					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (spot)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**3**
EMA(5)>EMA(20)	4.9381	26.5079	20.3085	17.2515	**1**
EMA(5)>EMA(30)	21.3023	12.2120	14.6922	16.0688	**2**
Average	**13.1202**	**19.3599**	**17.5004**	**16.6602**	
No RSI Sharpe					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs Signal (Q+1)**	**Ranking**
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**2**
EMA(5)>EMA(20)	13.8624	9.1387	9.7420	10.9143	**1**
EMA(5)>EMA(30)	5.8705	6.3501	6.3552	6.1919	**3**
Average	**9.8664**	**7.7444**	**8.0486**	**8.5531**	

RSI 50/50 Sharpe					
Spot signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (spot)	Ranking
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**3**
EMA(5)>EMA(20)	3.9187	23.0770	6.1624	11.0527	**2**
EMA(5)>EMA(30)	21.9990	17.5553	20.0238	19.8594	**1**
Average	**12.9589**	**20.3162**	**13.0931**	**15.4560**	
RSI 50/50 Sharpe					
Quarter signal	**NBP**	**NCG**	**TTF**	**Average across all hubs** Signal (Q+1)	Ranking
Buy and hold	**6.1188**	**8.0291**	**8.2180**	**7.4553**	**2**
EMA(5)>EMA(20)	24.7147	23.0964	24.4292	24.0801	**1**
EMA(5)>EMA(30)	6.8649	7.2944	7.5827	7.2473	**3**
Average	**15.7898**	**15.1954**	**16.0059**	**15.6637**	

RSI 70/30 Sharpe

Spot signal				Average across all hubs	
	NBP	NCG	TTF	Signal (spot)	Ranking
Buy and hold	6.1188	8.0291	8.2180	7.4553	3
EMA(5)>EMA(20)	6.0959	31.8464	11.5015	16.4813	1
EMA(5)>EMA(30)	21.9990	5.4652	8.3198	11.9280	2
Average	14.0474	18.6558	9.9106	14.2046	
RSI 70/30 Sharpe					
Quarter signal				Average across all hubs	
	NBP	NCG	TTF	Signal (Q+1)	Ranking
Buy and hold	6.1188	8.0291	8.2180	7.4553	2
EMA(5)>EMA(20)	24.7147	18.3279	19.1218	20.7215	1
EMA(5)>EMA(30)	7.1089	6.5138	6.0409	6.5546	3
Average	15.9118	12.4209	12.5814	13.6380	

RSI 80/20 Sharpe					
Spot signal				Average across all hubs	
	NBP	NCG	TTF	Signal (spot)	Ranking
Buy and hold	6.1188	8.0291	8.2180	7.4553	3
EMA(5)>EMA(20)	9.0851	37.6836	14.7734	20.5140	1
EMA(5)>EMA(30)	19.6131	7.1908	7.9447	11.5829	2
Average	14.3491	22.4372	11.3591	16.0485	
RSI 80/20 Sharpe					
Quarter signal	Average across all hubs				
	NBP	NCG	TTF	Signal (Q+1)	Ranking
Buy and hold	6.1188	8.0291	8.2180	7.4553	2
EMA(5)>EMA(20)	24.7147	23.0964	24.4292	24.0801	1
EMA(5)>EMA(30)	6.8649	7.2944	7.5827	7.2473	3
Average	15.7898	15.1954	16.0059	15.6637	

Table 31: Sharpe ratio for the exponential moving average strategies

We will now see how our strategies' Sharpe ratio compared to the buy and hold strategy. In general, all the results are good and somewhat similar – with/without RSI, and analyzing the spot data, both EMA/EMA strategies delivered a better performance measure than the buy and hold. Analyzing the quarter data, both with and without RSI, in all cases the EMA(5)>EMA(20) strategy was able to beat the buy and hold by a good margin while the EMA(5)>EMA(30) did not, all though the EMA(5)>EMA(30) still delivered positive results.

	No RSI		RSI 50/50		RSI 70/30		RSI 80/20			
Strategy	Spot	Q+1	Spot	Q+1	Spot	Q+1	Spot	Q+1	Average	Rank
EMA(5)>EMA(20)	17.2515	10.9143	11.0527	24.0801	16.4813	20.7215	20.5140	24.0801	18.1369	**1**
EMA(5)>EMA(30)	16.0688	6.1919	19.8594	7.2473	11.9280	6.5546	11.5829	7.2473	10.8350	**2**

Table 32: Sharpe ratio for the exponential moving average strategies

From the table above we can see that on average across all hubs and with the different filters, the EMA(5)>EMA(20) strategy delivered the best performance measure with 18.1369. That is a good result in comparison to the Sharpe ratio of 10.8350 from the EMA(5)>EMA(30). And so, the EMA(5)>EMA(20) was the best out of the two.

To summarize, looking at the performance measures from our EMA/EMA strategies we have found that analyzing the spot data fit our strategies better, giving a higher Sharpe than the results from the quarter data. Further we have found that using an RSI filter was beneficial, and all of the three RSI filters managed to deliver a better Sharpe ratio than using the signals only. The RSI 80/20 performed best with an average Sharpe ratio of 15.8561.

When we compared our results to the buy and hold strategy all of the results were similar – analyzing the spot data both EMA/EMA strategies managed to beat the buy and hold, but analyzing the quarter data only the EMA(5)>EMA(20) strategy managed to do so. This was the best strategy out of the two – even though the EMA(5)>EMA(30) also delivered positive results.

Key findings

In this section we will go through the key findings from all our tests done with the various moving average crossover strategies. Here we will look into which price data worked best for our strategies, which RSI filter gave on average the best performance measure, and which crossover strategies that on average gave the best results. We will look into the Sharpe ratios here since they measure the risk adjusted return.

Sharpe ratio	**Spot**	**Q+1**	**Average**	**Ranking**
No RSI	18.0442	17.5755	17.8099	4
RSI 50/50	40.5116	19.2102	29.8609	2
RSI 70/30	36.3780	15.8621	26.1201	3
RSI 80/20	40.8190	19.5108	30.1649	1
Average	33.9382	18.0397		
Ranking	1	2		

Table 33: Summary of results

From table 33 we can see that utilizing the spot signals gave on average the best Sharpe ratio at 33.9382, compared to 18.0397 from the quarter signals. With the three different RSI settings, using the spot signals gave on average the highest result, and without RSI the spot signals still gave on average a slightly better Sharpe than using the quarter signals. And so we can conclude that analyzing the spot price data worked best for our technical trading strategies.

From the same table we can also see how only utilizing the signals compared to the strategies where we included various variations of the RSI filter. The RSI 80/20 filter gave on average the best performance measure at 30.1649, with the RSI 50/50 filter close behind with an average Sharpe of 29.8609. The RSI 70/30 filter came 3rd at 26.1201 and finally using no RSI had on average the worst Sharpe ratio at 17.8099. From these results we can conclude that it was beneficial to include the RSI filter in our strategies, since with all variations, the average Sharpe with an RSI filter was higher than in the tests without RSI. And from the different filters, the 80/20 gave the best results with the 50/50 filter close behind.

We will now continue to see which of the moving average combinations gave the best results on average across the different gas hubs and the different RSI filters, and which managed to outperform the buy and hold strategy.

SMA	Average	Rank
(5)>(20)	7.1182	7
(1)>(10)	-4.0255	11
(1)>(20)	-2.6989	10
(2)>(10)	5.0066	9
(5)>(10)	11.9975	2
EMA/SMA		
(5)>(20)	5.5156	8
(5)>(30)	11.3756	3
(5)>(5)	7.1789	6
EMA		
(5)>(20)	18.1369	1
(5)>(30)	10.835	4
Buy and hold	7.4553	5

Table 34: Summary of results

From table 34 we can see that 4/10 of the moving average crossover combinations managed to deliver a better Sharpe ratio than the buy and hold strategy. The strategy that gave the best Sharpe ratio was the EMA (5)>(20) strategy, with an average of 18.1369. The SMA (5)>(10) strategy came second with an average Sharpe of 11.9975, the EMA/SMA strategy (5)>(30)

came in third place with 11.3756, and then the last strategy that beat the buy and hold was the EMA(5)>(30) strategy which came in fourth place with an average Sharpe of 10.835.

From the various technical trading strategies we have tested, we've found that utilizing the spot signals gave on average a better Sharpe ratio than the quarter signals. Further we have found that using an RSI filter was clearly beneficial, and all three variations of the RSI filters we have tested managed to deliver better results than utilizing the signals only without RSI.

When it comes to the different moving average crossover strategies, some combinations worked better than others. In total – 4/10 of the different strategies managed to deliver a better Sharpe ratio than the buy and hold. The strategies that worked best was the EMA(5)>(20) strategy, then the SMA (5)>(10) came second, with the EMA/SMA (5)>(30) strategy third and finally the EMA(5)>(30) strategy as the last one that managed to deliver a better average Sharpe ratio than the buy and hold strategy.

Conclusion

In this thesis, with the help of Westgass AS, we have researched the performance of technical trading strategies to answer if they could outperform a buy and hold strategy in the European natural gas market. To answer this research question there were several things we had to find out before we could start testing the strategies. We had to research the European natural gas market, get an overview of the fundamental supply/demand situation, and learn about trading in the different hubs and which contract types were available and fit our strategies the most. In addition to technical analysis and the strategies themselves, we also had to research transaction costs, and other things that came up along the way. We wanted to trade the natural gas contracts as close to a typical futures contract as possible, and therefore decided to use the quarter ahead contracts as they gave the longest trading window before being forced to either close the position or buy/deliver the gas.

For our market selection we wanted to put the odds in our favor and chose the three most liquid markets: TTF, NCG and NBP. High liquidity is advantageous for technical trading strategies, and so we chose these markets as we believed they would give the best results. We had price data available from 05.10.2017 to 29.01.2019 and so this was the window where we could test our strategies. We also had to research the performance of a buy and hold strategy in the same period, to see how our strategies would compare.

We wanted to test strategies that could be automated so it wouldn't be a requirement that the person who utilized the strategies had to be a good trader, but rather that they could rely on the strategies themselves. And so, we chose moving average crossover strategies with and without an RSI filter, and we also tested different variants of the RSI filter to see which suited the gas markets the most.

After we found all the information we needed we conducted the tests. For our strategies we tested a total of 10 different simple and exponential moving average crossover combinations, in addition to testing them with three different variants of the RSI oscillator. We have tested all of these analyzing the quarter data and the day ahead data, and this equals to 80 different strategies in total and 240 different results. To measure our performance we looked at the returns, standard deviation and Sharpe ratio.

When looking at the returns, 99 out of the 240 results beat our buy and hold strategy, giving a success rate of 41,25%. The exponential moving average strategies performed best, with 30 of 48 beating the buy and hold strategy (62,5%), while the simple moving average strategies beat the buy and hold in 44 of 120 cases (36,67%) and our hybrid strategies with both exponential and simple moving average beat the buy and hold in 25 out of 72 variations (34,72%).

If we further look at the standard deviation, 144 out of the 240 results performed better than the buy and hold strategy, giving a success rate of 60%. Our hybrid strategies with exponential and simple moving average had the highest success rate with 66,67%, followed by the exponential moving average strategies with 58,33% and the simple moving average strategies at 56,67%.

The Sharpe ratio gives valuable information about the performance of the different strategies, since it uses both the return and the risk of a strategy when calculating its ratio. Of the 240 results, 103 of them outperformed the buy and hold strategy, providing a success rate of 42,92%. The exponential moving average strategies performed best with 66,67% of the results outperforming the buy and hold strategy. The hybrid strategies had a success rate of 37,5%, and the simple moving average strategies had a success rate close behind at 36,67%.

Looking at our results we found that a lot of these strategies were able to outperform a buy and hold strategy, and that is by looking at all the factors. Returns, risk, and the performance measure that includes both. And that answers our research question: A good amount of the technical trading strategies were indeed able to outperform a buy and hold strategy, and so for

those who look to profit from the European natural gas market, automated technical trading strategies are definitely worth taking a look into. With that said financial markets are always changing, and due to limited resources, we have only been able to backtest these strategies with the information we had available. We have not tested them live, and past performance is no guarantee of future results. It would be advisable to test the strategies in real-time first before applying them.

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