Automated Trading using a Dip Searching Strategy

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Abstract

The purpose of this thesis is to create algorithmic trading strategies based on the idea that the OMXS30 index will behave in a certain way a dip in the market. These strategies are created because one wants to find a way of making profit on the OMXS30 index. To build the strategies a thorough study of the index has been made and then different statistical methods are used when designing the strategies. All of the four strategies generate a profit when they were tested, the net results are different for each strategy. The conclusions drawn in this thesis are that there are many ways of creating algorithmic strategies, but when using a strategy which becomes active after a dip, there is potential profit to be made.

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Contents

Chapter 1

Introduction

This introduction has five part. The first part is in section 1.1 and is called background. In section 1.1 are some background information of algorithmic trading are presented and also different types of algorithmic trading strategies are surveyed. In section 1.2 the aims of this master thesis are presented. In the next section, section 1.3, named scope, are the different data sets discussed. Section 1.4 has a brief presentation about what methods are used to solve the aims of this project. At last the section 1.5 called outline summarizes the report and describes briefly what the next chapters are about.

1.1 Background

The OMXS30 index is the main index on the Stockholm stock market. The OMXS30 index consists of shares from the 30 large companies on the Stockholm stock market. When trading with indexes one buys or sell futures contracts on the index, hence it is similar to trade with futures contracts on commodities. An index futures contract works in the same way as futures contracts for stocks. The difference is that instead of betting on how a stock will move in the future a bet is made on how the market will move in the future.

The value, V, of a futures contract on OMXS30 is worth

$$V = 100 \cdot (\text{the current value of the index}).$$

To trade with futures contracts on OMXS30 a security margin of 10 per cent of the current futures price is needed. It is important to trade with futures contracts with high liquidity or else the spread will eat up the profit, [6]. The OMXS30 index is one of the most liquid securities on the swedish market .

A futures contract is a contract that gives the right to buy or sell a commodity of a certain standardized quality on a specific date in the future called the delivery date. For example let a futures contract of a certain commodity be bought at the price F_0. The next day the futures contracts price is F_1 then the contract holder needs to pay or receive the difference between the two prices depending on if the price change is a loss or a gain. To handle these adjustments every day a margin account needs to be open by the contract holder. On this account a specific amount of money needs to be put, often $5 - 10\%$ of the contracts value. If this amounts descends below a certain maintenance margin level a margin call is made and the contract holder needs to add money to the account. If this is not done the futures position will be closed out by taking an equal and an opposite position. The value of a futures contract is always zeros since it is always marked to market, [3].

1.1.1 Algorithmic trading, in general

An algorithmic trading system is a trading system which uses advanced mathematical models for making transaction decisions in the financial market. These algorithms are built in a computer program and therefore this type of trading is sometimes called black box trading. Another name for algorithmic trading is automated trading.

The strict rules in these algorithm attempts to decide when the optimal time for an order to be placed. Often this type of trading is used by large institutional investors since they usually purchase a large amount of shares every day, [7].

1.1.2 Different types of algorithmic trading

There are different ways of building automated trading strategies. Below some of these strategies will be surveyed.

One common strategy is based on arbitrage theory. This strategy looks for several things, among them interest rate parity in the foreign exchange market. The arbitrage occurs when several different purchases are based on the same numbers but the interest rates do not match up. The main task for these algorithms are to detect market inefficiencies. These strategies are called basic arbitrage strategies, [5].

An other type of strategy is called transaction reduction cost also known as "iceberging". This type of strategy finds a way to break down large orders in smaller pieces over time, in order to get the best possible price. Other reasons for breaking down large trades can be to try to hide big orders for other market participants or to try to minimize market impact, [5]. This type of strategy is thus used in different ways with different purposes.

Market making is one other method use in algorithmic trading. The concept for this strategy is to offer to buy below market price or offer to sell above market price, and then to try to benefit from the spread, [8].

There also exist benchmarking strategies that tries to mimic the indices returns. Other automated strategies are those called "sniffers" and "gamers". "Sniffers" are strategies that detect volatile and unstable markets. "Gamers" are strategies that detects icebergs. When an iceberg is discovered the strategy uses this information to try to gain from knowing that large orders are coming in over time, [8].

1.2 Aim

The aim for this master thesis is to find automated trading strategies that are based on the futures prices on the OMXS30 index. The goal is to find models that work on daily data but also to find models that work on five minute data. It will be possible to buy long and sell short in these models. The main goal is to find strategies that will render a positive income, over time.

1.3 Scope

The scope of this report is only the analysis of data from futures contracts of the index OMXS30. Backtesting is done with data from 2001/11/21 to 2009/04/14 when studying daily data. For the five minute data the backtesting is done with data from 2005/01/01 to 2009/04/14.

The platform used to create the strategies are a platform called Treetop Hydra and are manufactured by the enterprise Treetop Capital AB, where this master thesis was preformed. Treetop Hydra is a platform which is able to evaluate trading strategies by displaying different parameters and in this platform new trading strategies can be built.

1.4 Method

The method used to create the strategies in this thesis are based on a dip searching technique, this will be explained in Chapter 3 and Chapter 4. When the strategy detects a dip it should react. The reaction depends on what the other circumstances are. Other techniques used are based on an estimation of the inclination of the trend and the volatility. After these calculations are made the strategy decides what to do next. For each strategy only one contract is bought at a time.

1.5 Outline

Chapter 2 called Techniques explains different concepts and techniques used in this master thesis. Chapter 3 describes the dip searching strategy in general. Chapter 4 explains more in detail how the different dip-searching strategies are built. Chapter 5 contains presentations of the results for the different strategies and also some analysis of these results. Chapter 6 presents conclusions drawn from the result presentation and the analysis. At last Chapter 7 describes different improvements to me bade to the strategies, to increase the profit.

Chapter 2

Techniques

Different concepts and techniques are used when building the trading strategies. The techniques are presented and explained in this chapter. These techniques are used in the strategies based on both daily data and data updated every five minutes.

2.1 Average True Range

The concept of Average True Range , ATR, was first presented in 1978 by J. Welles Wilder in the book "New Concepts In Technical Trading Systems". He introduced ATR as a measure of volatility. A high value of the ATR means that the prices are moving a large amount during the given time period, which indicates that the volatility is high. A low value indicates that the prices are almost constant, thus the volatility is lower.

The ATR measure is based on the quantity of True Range, TR. The True Range is the difference between the highest and the lowest prices during a given time period for a specific stock or index. The TR was created by Wilder to take in to account the gaps between the closing price and the next time period's opening price. He invented this measure to find a better way of measuring the volatility than the measures used before this.

The TR is defined as

$$TR = \max \begin{cases} H_1 - L_1 \\ |H_1 - C_1| \\ |C_1 - L_1| \end{cases}$$

where H_1 is the latest time period's high price, L_1 is the latest time period's low price and C_1 is the previous time period's closing price.

The ATR is an exponential moving average of the TR. The moving average is defined as:

$$S_t = \alpha \cdot Y_{t-1} + (1-\alpha) \cdot S_{t-1}$$

where $\alpha = \frac{2}{N+1}$, Y_t is the observation at time t and S_t is the exponential moving average at time t. N is the number of time periods the smoothing is done over, [1].

When creating the automatic trading strategies a modified ATR is used, instead of $\alpha = \frac{2}{N+1}$ the value $\alpha = \frac{1}{N}$ is chosen.

Thus the ATR is defined as :

$$ATR = ATR_{yesterday} \cdot (1-\alpha) + \alpha \cdot TR \text{ , with } \alpha = \frac{1}{\text{period}}.$$

This last definition is taken from J. Welles Wilder's book "New Concepts In Technical Trading Systems" from 1978 mentioned earlier. Originally Wilder used ATR with a time period of 14 days, but here different time periods will be used. These are the 14 days ATR, the 100 days ATR and the 250 days ATR for the daily data and the one hour ATR for the five minute data.

2.2 Linear Regression

In the strategies to be presented later on the slopes of the different trends are to be estimated. The method used to estimate these slopes are based on linear regression. Linear regression is used to fit a straight line, $y = k \cdot x + m$, to a number of data points. For the price data the slope, k, is estimated by

$$k = \frac{\sum_{i=1}^{p}(pd_i - \overline{pd}) \cdot (x_i - \overline{x})}{\sum_{j=1}^{p}(x_j - \overline{x})^2},$$

where

$$\overline{x} = \frac{\sum_{i=1}^{p} x_i}{p}, \qquad \overline{pd_i} = \frac{\sum_{i=1}^{p} pd_i}{p}.$$

The pd_i is the price data at each time and x_i is the corresponding time at which the price data was collected and p is the time period in which the linear regression is made.

2.3 Profit Targets, Trailing Stops and Stop Losses

There are different ways of locking in a profit or limiting a loss. The algorithmic trading strategies use profit targets, trailing stops and stop losses.

A straightforward way of locking in profit is by placing a profit target. This profit target can be based on some percentage value of the entry price of the trade. This percentage value is called a profit target. The goal of a profit target is to protect a open equity profit. The level of the profit target is decided before or when the trade is entered. The profit target does not need to be a percentage value of the trade's entry price, for example it can also be a certain price level or a profit threshold, [4].

The definition of a profit target can be as follows:

Definition 2.1 *A profit target is an unconditional exit of a trade with a lock-in profit at some predetermined price or profit level.*

When the trade has met the profit target the trade is immediately closed and a profit is made, [4].

The disadvantage with using profit targets is that if the market continues to move in the same direction, the trade is already closed and the possibility of an additional gain is lost unless a new trade is opened.

In the trading strategies a volatility profit target is also used. The definition for that is:

Definition 2.2 *A volatility profit target is an unconditional exit of a trade at a profit level equal to a value based upon market volatility above (long position) or below (short position) the entry price.*

Here the market volatility is measure by the Average True Range. Both of the definition is taken from the book The Evaluation and Optimization of Trading Strategies, Second Edition, by Robert Pardo. See [4] for more information.

A trailing stop is a stop that continually advances in the same direction as a profitable market during the lifespan of the trade. There are both long trailing stop and short trailing stops. The definition of a trailing stop can be as below:

Definition 2.3 *A trailing stop is a dynamic order that moves up with new highs (long position) or down with lows (short position) in the market so as to preserve some predetermined proportion of open trade profit.*

As the definition 2.3 explains the stop will decrease or increase proportionally. The perfect trailing stop will protect as much of the open trading profit but also give space to encompass the market volatility. The trailing stop needs to give space to natural pull-backs in the market.

As for the profit target the trailing stop has a corresponding volatility stop. The definition is:

Definition 2.4 *A trailing volatility profit stop is an order to exit a position and is set at a point value based upon some measure of market volatility above the most current low price(short position) or below the most current high price (short position).*

These ways of placing trailing stops explain above are not the only ones. There are many ways, such as trailing stops based on the value of a moving average or based on support and resistance levels, [4].

There are also other ways of exiting trades. One way is by using stop losses. These stops are often based on some percentage value of the entry price. For example a stop loss can be placed at 10%, this means if the total loss is 10% an exit is made. The stop losses are sometimes called chaos losses as they try to bound the maximum loss.

The profit targets and the different type of losses can not totally prevent big losses. When the market is moving during night the opening price can be an other than the closing price, thus bigger losses can arise. With these targets and limits some losses can be limited and some gains can be preserved but there is still a risk to loose more than what originally was foreseen.

Chapter 3

A dip searching strategy

3.1 Before creating a trading strategy

There is a lot to think about when creating trading strategies.The most important point to think of is if the strategy let gains run and cut losses short. This is important because one does not want to hold a losing position for a long time and one wants to hold a winning position for as long as possible.

Next necessary thing that needs to be considered has to do with minimization of the risk for big losses. This is somewhat similar to the previous point. If one cuts the losses short the risk of losing a lot in one single trade is minimized.

It is also essential to have clear and predetermined criteria for entering, adding to and exiting trades when trading. This is important in general but when using algorithmic trading this is necessary since the algorithms are supposed to manage this all by themselves without any human interaction. It implies that there must exist an exit plan before the trade is entered. This exit strategy is caused by profit targets, trailing stops and other signals that will lead to an exit.

Finally there is not a good idea to add into a losing position, in hope that the position will change and start to go with a profit. The important thing to do is to cut the loss short and take a new position when the trend has changed, [2]. These are some of the most important aspects to consider before creating trading strategies.

3.2 How the dip-searching strategies work, in general

The dip strategy that issued in this master thesis is based on a quite simple principle. The strategies are based on the theory that when there has been a movement in one direction for some time but then the trend changes direction, be prepared to enter. If the trend changes direction again and moves in the first direction enter the trade, else let it be. When the trade is entered follow the index for a while and hopefully a profit will be made.

To decide whether there is a dip in the trend the historical volatility is measured and also earlier movements in the index price are measured. It is important to put the movements of the potential dip into relation with the natural volatility of the index. This needs to be done because the movements have to be bigger than the natural motion of the index to prevent entering a trade on the normal oscillation of the index.

When to enter a trade is decided differently in each specific strategy depending on what the purpose for the strategy is. But generally, in this report the entering prices are based on triggers. These triggers are built upon the fact that the index price moves sufficiently much in some direction but also on other preferences as the volatility and how "strong" the trend is.

When a trade is entered different types of profit target, stop losses and trailing stops are set. These different quantities are based on parameters as the slope of the trend and the Average True Range, ATR.

There are two ways to think about when to enter a trade in the dip strategy. For simplicity when explaining this the trade is a long trade. The first thought is to enter the trade as close to the dip's bottom as possible. The other way is to enter the trade when the index price has passed the previous high value, before the dip. The first way of entering is harder to detect, since in some sense one needs to guess when the bottom is. Hence in this master thesis the second way of entering a trade is used in the dip-searching strategies.

Even though the index prices passes the trigger it is not certain that a trade will be entered. To decide if the trigger is a "good" signal the volatility, in form of the ATR and the trend are to be estimated. When comparing these to certain predefined values the signal is classified as a "good" or a "bad" signal.

For the strategies based on daily data the volatility is the most important factor to decide whether the signal is "good" or not. For the five minute strategies the linear regression of the trend is the most central factor when to decide whether the signal is "good" or "bad".

The reason for separating buying long and selling short in different strategies is that there is easier to understand what will happen when the strategies start to buy and sell contracts. If it is possible to buy long and sell short in the same strategy there is a possibility that a long contract and a short contract will cooperate and create situation not at all expected. This can create both profitable situations but also but also non-profitable ones and that is something that wants to be avoided. That is the reason for dividing them into different strategies.

Chapter 4

The strategies, in detail

In this chapter are the strategies presented more in detail. There are four section, one for each strategy. There are two strategies based on daily data and two based on data updated every five minute.

4.1 The daily long trading strategy

The basic concept of this strategy is to use the above presented dip strategy to long trade on daily data. The first thing that happens when a trading day is over is that the ATR for 250 days, $ATR(250)$, and the 14 days ATR, $ATR(14)$, are calculated. For a more detailed explanation of how this is done see chapter 2.1. After that the highest, HH_6, and the lowest, LL_6, price for the last six trading days are selected. When HH_6, LL_6 and $ATR(250)$ are known the quotient $VolQuota = \frac{HH_6 - LL_6}{ATR(250)}$ is calculated.

The next step for the strategy is to check whether there is a trade open or not. If there is no trade open the strategy will calculate a trigger, T, that will be used as an entry signal. To get T the first thing done is to calculate a volatility quantity expressed as a percentage of the latest closing price of the index, C_1. This volatility is thus calculated as:

$$VolPct = \frac{100 * ATR(14)}{C_1}.$$

By studying earlier values of this quantity a lowest value of $VolPct$ is set. Before calculating the trigger T, a trigger factor, TF, is to be defined. TF gets the value 1 when the $VolPct$ reaches a certain top value, and when the lowest value of the $VolPct$ is hit the value of the trigger factor is 0.05. Yet an other value is also added to TF. This value is a proportion of the value between the latest six days highest prices and lowest prices. This difference is then divided by 5 and added on to TF. The a trigger T_0 is the defined as:

$$T_0 = LL_6 + (HH_6 - LL_6) * TF, \text{ and then}$$

$$T = \max(H_1, T_0), \text{ where } H_1 \text{ is the latest high price.}$$

This trigger T will be a trigger that the strategy will try to buy on, if the opportunity is given. But some criteria need to be fulfilled for this to be a trigger that will be accepted. Due to how the trigger is constructed it will react after there has been a dip in the index, when the index starts to move up again. This is the reason for the strategy to be called a dip searching strategy. The conditions are that the value of $VolQuota$ needs to be less then the value 5.0 and the value of $ATR(250)$ needs to be less than the value of 15.

When the strategy tries to buy an initial stop and an initial profit target is set. Below are the definitions for these quantities:

$$InitPT = T + InitF \cdot ATR(14)$$
$$InitStop = T - InitF \cdot ATR(14)$$

Here $InitF = 2.0$.

If the index price the next trading day hits the trigger and the above mentioned properties are fulfilled an entrance of the trade is made.

When the strategy has an active trade the strategy's task is to calculate a trailing stop and a profit target each time a new bar of daily data is available.

The trailing stop first gets the initial value which is the same value as the initial stop. This only happens if the trade is just entered and no old trailing stop exists. The trailing stop is based on this initial value. If the index price moves up the trailing stop will follow but if the index price moves down the trailing stop will not be lower than it already is. When the trailing stop increases its value the increase is based on the estimated slope of the trend. This estimation is done by linear regression as mention earlier. The linear regression is done for the five latest trading days for both the highest and the lowest prices. Thus two different slopes are given, the smallest of these two values is chosen to be the slope added to the trailing stop. The value of the slope is multiplied by a factor, which has different values depending on how volatile it has been earlier. When this factor is calculated the volatility is measured by a quotient as $\frac{ATR(250)}{ATR(14)}$.

The value of the profit target does not change. The profit target value is 3.5% higher than the entry price of the trade. The value of 3.5% is chosen because it is a value not to far from the entry price and it also gives a quite large profit, in per cent, for each trade, if the target is hit.

4.2 The daily short selling strategy

The short selling strategy uses $ATR(100)$ and $ATR(14)$ as the measure of volatility. Similarly to the long strategy the quota $VolPct = \frac{100 \cdot ATR(100)}{C_1}$ is used to describe the volatility as well. The difference from the long strategy is that $ATR(100)$ is used instead of $ATR(14)$. These above mentioned quantities are calculated after each new trading day.

The next step in the strategy is to estimate the trend. This is done by linear regression where the quantity k is the slope, hence the estimated trend. This estimation is with a look back of 9 days and the linear regression is done, separately, for the 9 days highest prices and the 9 days lowest prices. Then the average value is take from these two values and an estimation of the trend is found. The average slope for the 5 last days, k_5, is also calculated. This is estimated in the same way as k, with linear regression.

Next if both the slopes k and k_5 are greater than zero the trigger,T_0 is defined as $T_0 = L_1 - 0.5 \cdot ATR(14)$, where L_1 is the latest trading day's lowest price. If some of these quantities are smaller than zero the trigger is set to be the smallest value of the index price for the latest six days, LL_6.

After that an other factor called trigger bound, $TriggerBound$, is calculated. Firstly a bound b is defined as $b = \min\{\max(2, 1.5 \cdot ATR(100)), 10\}$. The trigger bound is thus defined as $TriggerBound = L_1 - b$. Finally a new trigger, T is calculated as $T = \min(T_0, TriggerBound)$. $VolPct$ needs to be bigger than 2.5 and the latest closing price, C_1, needs to be bigger than the trigger T or else an attempt to short a contract will not be made. The construction of this trigger will create a dip searching behaviour, as for the long trading daily strategy. This strategy will react when there has been a peak in the index. If the index starts to move done after the peak the trigger will be more likely to become active, that is way this strategy has got the name dip searching.

The initial stop is set to $InitStop = H_1 + 2 \cdot ATR(14)$ and the initial profit target is $InitPT = T - ATR(14)$, H_1 is the latest trading day's highest price.

If a trade is entered the trailing stop is to be calculated. The first thing done is to estimate the trend. This is done once again by linear regression based on the five latest trading days and here is the slope, k, is estimated by the maximum of the slope for the highest prices and the lowest prices. The expression for the trailing stop looks like this:

$$Stop = oldStop + SF \cdot k$$

The factor SF is a factor that takes different numerical values depending on the volatility. The quantity $oldStop$ is the value for the trailing stop the previous trading day. As for the long strategy the trailing stop can only move in one direction and that is downwards.

The trailing stop will get an other value if the estimated slope of the trend is strongly positive. Then the stop will get the value:

$$Stop = H_1 + (EntryPrice - H_1)/2,$$

where the $EntryPrice$ is the price when the trade is entered and H_1 is the highest price the previous trading day.

A difference from the daily long strategy is that this strategy also has a stop loss. The strategy has this factor because if there is a fast change in the index price a stop loss will prevent very big losses. This strategy is active when the market is trending downwards, i.e there is a bear market, and in downward trending market the volatility is higher than in an upwards trending market, i.e in a bull market. Thus since the strategy is active in fast changing market the stop loss will work as an extra safety net. This stop loss is put to 3 % above the entry price of the trade.

The profit target used in this strategy is fixed. It is only the initial profit target that is based on the Average True Range ,ATR. The profit target is put to 85 % of the entry price of the trade. This level was found when backtesting was done for the OMXS30 index.

4.3 The long trading strategy based on five minute data

The long strategy based on five minute data is quite similar to the long strategy based on daily data. The first difference is that the Average True Range, ATR, is not based on daily data but on five minute data. The ATR used has a look back on 12 time periods, which means that the look back is an hour, hence this ATR gets the name $ATRHour$.

An other difference from the daily strategy is that the trigger, T, can be set in yet an other way than for the daily data. If the highest price of the latest bar is larger than the 30 periods highest value, HH_{30}, then the trigger is set to be this high value, thus

$$T = H_1, \text{ if } H_1 > HH_{30}.$$

If this condition is not fulfilled the T set in the same way as for daily data, with all the parameter adjusted to the five minute data set. Also the quantity $VolPct$ is based on the $ATRHour$ instead of the $ATR(14)$, which is the ATR with a look back of 14 days.

Next a quantity called $TriggerFactor$ is calculated and this factor is based on the volatility. The $TriggerFactor$ hits its lowest value, which is 0.4, when the $VolPct$ hits its lowest value. The $TriggerFactor$ is 1 when the $VolPct$ has the value 0.32. If $VolPct$ is larger the $TriggerFactor$ will get an even bigger value. As for the daily strategy an other factor is added to the $TriggerFactor$. This new factor is based on the 12 periods highest value, HH_{12}, and lowest value, LL_{12}.

The T is than set to be

$$T = \max(H_1 + 1.0, LL_{12} + (HH_{12} - LL_{12}) * TriggerFactor).$$

Since the long trading strategy based on five minute data is created in a similar way as the long trading strategy based on daily data, the dip searching property is also inherited.

After that the strategy estimates the trend. This is done by a linear regression based on the 12 latest periods, this give the slope, k. This slope k needs to be bigger than 0.1 to yield a trigger that is accepted. Also the $ATRHour$ needs to be smaller than 1.5 to allow the strategy to buy a contract. Before the strategy can buy a contract initial stops and initial profit targets are set. These are defined as

$$InitStop = 0.99 \cdot T,$$
$$InitPT = 1.01 \cdot T.$$

If a trade is initiated the strategy starts to calculate different types of stops and profit targets. First a trailing stop is calculated. This trailing stop is based on a linear regression of the slope for the five latest time periods, k_5, and is defined as $TrailingStop = oldStop + 0.3 \cdot k_5$, where the $oldStop$ is the trailing stop value for the previous bar. This trailing stop has the constraint that it can not be smaller, it will only increase.

Next the strategy calculates a profit target, PT, which can be seen as a trailing profit target. This profit target is defined as $PT = oldPT + 0.25 \cdot k_5$, where the $oldPT$ is the previous time period's profit target.

These are not the only profit targets and stops that exist in this strategy there are also one more stop and profit target. Both the stop and the profit target have something to do with a quantity called the expectancy, E. The expectancy is defined as

$$E = \sum_{i=1}^{n} \frac{(ExitPrice_i - EntryPrice_i)/(EntryPrice_i - InitStop_i)}{n}.$$

The $EntryPrice_i$ and the $ExitPrice_i$ are the entry price and exit price for a specific trade i. $InitStop_i$ is the initial stop for this specific trade i.

If E is larger than 0.4 an other stop is added. This stop is $ExtraStop$ and is defined as $ExtraStop = H_1 - 0.25$, where H_1 is the latest trading day's highest price. This stop is placed to try to preserve some of the gain if the trade starts to go down after this point. The $ExtraPT$ is placed if the E is smaller than -0.2. This profit target is defined as $ExtratPT = H_1 + 0.75$. With this target the strategy tries to decrease the loss in an already losing trade.

4.4 The short selling strategy based on five minute data

This strategy is quite similar to the long strategy based on data updated every five minute. The trigger is almost calculated in the same way but here no consideration is taken to the 30 latest time periods highest value. The quantity $VolPct$ is once again based on the $ATRHour$ as for the five minute long trading strategy. The $TriggerFactor$ is also calculated in the same way but the minimum value of $VolPct = 0.18$. The $TriggerFactor$ gets the value of 0.2 if the $VolPct$ is less than or equal to 0.18. If $VolPct = 0.38$ the $TriggerFactor$ gets the value 1. If the $VolPct$ is bigger than 0.38 the trigger is greater than 1. As for the other strategy built in the same way an other factor is added to the $TriggerFactor$. This new factor is based on the latest 12 time periods highest value, HH_{12} and lowest value, LL_{12}. Thus,

$$T = \max(L_1 - 1.75, HH_{12} - (HH_{12} - LL_{12}) * TriggerFactor),$$

where L_1 is the latest bar's lowest value. The dip searching behaviour appears in the construction of the trigger. The trigger is built in such a way that the value of the trigger T will approach the value of the index after a dip has occurred in the index market, which will make it more likely for the trigger to be hit by the index and an entrance will be made.

When the trigger is calculated a verification of the trigger needs to be done to make sure that the trigger is a "good" signal. This is done by estimating the trend for the 12 latest time periods, k_{12}. This k_{12} need to be smaller than zero to generate a "good" signal. Also a linear regression based on daily data for the 5 latest days are done. This slope k_{5days} needs to be smaller than zero, as well, to generate a "good" signal and the $ATRHour$ needs to be bigger than 1.8. This last condition comes from the fact that the volatility usually is larger when the market is going down.

The initial stop and initial profit target are set to be

$$InitPT = 0.98 \cdot T,$$
$$InitStop = 1.05 \cdot T.$$

If a trade is entered the strategy continues by calculating stops and profit targets. Similarly to the five minute long trading strategy there are different types of stops and profit targets.

Firstly a trailing stop is determined. This trailing stop is

$$TrailingStop = oldStop - 0.1 \cdot k_5.$$

The k_5 is a linear regression of the slope based on the five latest time periods. The trailing stop can only decrease.

The profit target is once again some kind of trailing profit target. This profit target is defined as

$$TrailingPT = oldPT - 0.1 \cdot k_5.$$

There are also a stop and a profit target based on the expectancy, E, as for the long trading five minute strategy. These quantities are called $ExtraStop$ and $ExtraPT$ and are defined as

$$ExtraStop = H_1 + 0.5, \text{ if the } E > 0.75$$
$$ExtraPT = L_1 - 1.0, \text{ if the } E \leq -0.5,$$

where H_1 and L_1 have the same definitions as mentioned earlier.

The purpose for the $ExtraStop$ is to preserve some profit if the market turns in a non-profitable direction and the purpose for the $ExtraPT$ is to try decrease the loss in an already losing trade.

Chapter 5

Results and analysis

In this chapter the results are presented for the strategies. The results are based on the data set from November 2002 to May 2009 for the daily data and from January 2005 to May 2009 for the five minute data. Below is a plot of how the index has moved, based on daily data, during the specific time period.

Figure 5.1: The chart for the OMXS30 index based on daily data during November 2002 to May 2009.

Below is how the OMXS30 index has moved, based on five minute data, during the specific time period.

Figure 5.2: The chart of of the OMXS30 index based on five minute data between January 2005 to May 2009.

5.1 Results for the daily long trading strategy

The strategy has during the time period November 2002 to April 2009, made 44 trades. 25 of these trades were winning trades and 19 were losing trades. This gives the strategy a winning percentage of 56.8%. The profit made is measured in points.

Below is a plot of the how the trading strategy has traded.

Figure 5.3: The chart for the daily long trading strategy with trades marked.

As the plot shows is the strategy only buying when the trend is going up, but the typical dip behaviour also needs to precede if the strategy should try to enter a trade.

A trade is in average 11 trading days long, but a winning trade is about 14 trading days long and a losing trade is 8 trading days long. This behaviour is something that strategy is built to do. One wants the strategy to exit as soon as possible if the trade is thought to be a losing trade, since one wishes to cut the losses short.

The average profit/loss is defined as $\frac{Profit}{N}$, where N is the total number of trades. For the strategy during the given time period, the average trade makes a profit of 10.4 points or in per cent, about 1.2%. If winning and losing trades are separated the winning trades give about 28.1 points profit and the losing trades are losing about 12.9 points loss.

An other quantity measure to estimate the performance of the strategy is something called the expectancy. The expectancy, E, is defined as in chapter 4.3. The expectancy is given to be $E = 0.49$. If one, once again, separates the winning and the losing trades the values of the expectancy are $E_{winning} = 1.4$ and $E_{losing} = -0.7$.

The total gain for this strategy is about 460 points or about 50% more than what originally was invested. Below is the profit chart for this strategy during the specific period. Here all time is included not only the time when there is a active trade. When the profit chart is on the same level for some time this means that the strategy does not have a active trade during that time.

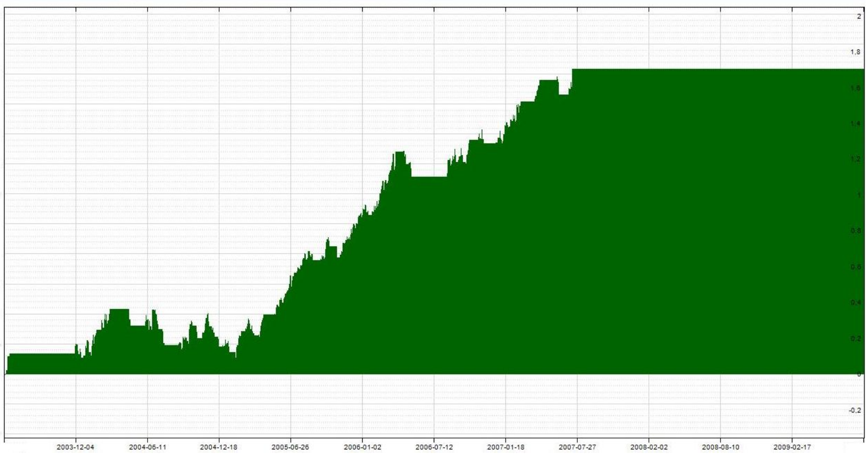

Figure 5.4: The profit chart for the long trading daily strategy between November 2002 to May 2009.

Below is the profit chart with the time not in trades removed from the chart.

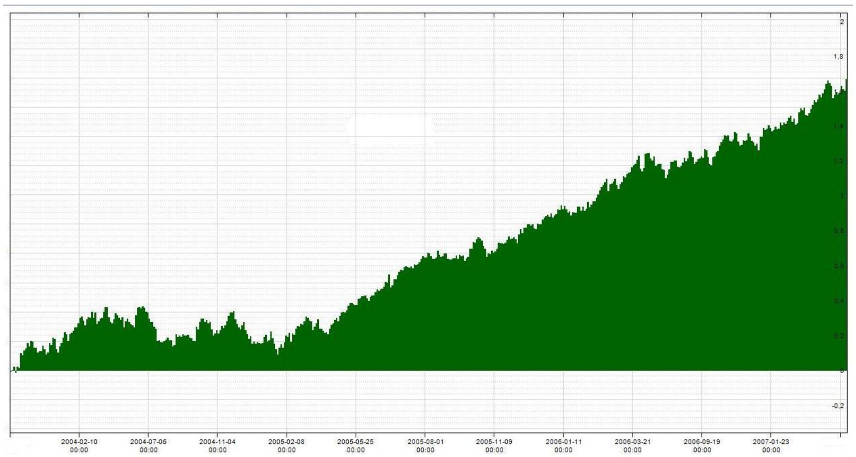

Figure 5.5: The profit chart for the long trading daily strategy only with the time in trades.

A quantity called draw down is also measured, or more exact it is called maximal draw down. The draw down is defined as

$$Drawdown = CurrentProfit - MaximumProfit.$$

The maximum draw down is, as one expects from the name, the maximal value of the draw down that has been during the active time of the strategy. For this strategy the value of the maximum draw down is about 60 points or about 8.3%.

The pay-off ratio for the strategy is given to be about 2.1. The pay-off ratio is defined as:

$$\text{Pay-off} = \frac{AverageProfit}{AverageLoss}.$$

Since this value is 2.1 this means that the profits are about two times bigger than the losses.

If the risk in some sense need to be taken in to account the property of risk adjusted return is one way to do that. The risk adjusted return, RAR, is defined as:

$$RAR = \frac{Profit}{|Maximal\ drawdown|}.$$

This value is 6.2% or measure in points 7.7 points.

The risk analysis is also made by studying the the returns. The profit, P, made during a trade is defined as

$$P = V_T^S - V_0^S,$$

where V_T^S is the value of the contract at time T, when trading as the strategy indicates and V_0^S is the value of the trade when the trade is entered. One can assume that the relation between V_T^S and V_0^S are as follows

$$V_T^S = (1+r)^T \cdot V_0^S, \text{ where } r \text{ is return.}$$

This gives the following expression for the return $r = (\frac{V_T^S}{V_0^S})^{\frac{1}{T}} - 1$, r is known as the arithmetic return. The return, for the daily long trading strategy, is represented in the histogram below.

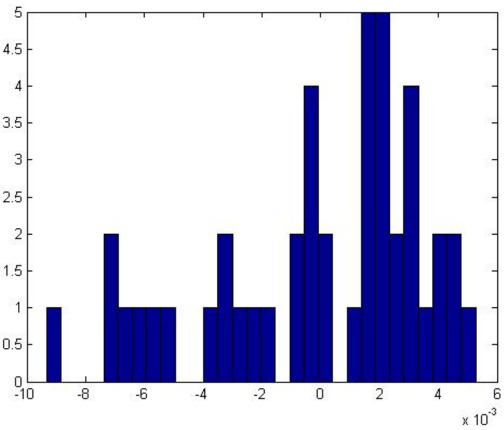

Figure 5.6: Histogram for the return for the daily long trading strategy.

The mean value for the return, m_r^{DL} is just above zero and the standard deviation for the return, σ_r^{DL} is $\sigma_r^{DL} = 0.00374$. The empirical Value at Risk at 95%, $\text{VaR}_{0.95}^{DL}(r)$, is also calculated. This is done by sorting the return and then choosing the $[n(1-\alpha)]+1$ return as the VaR value. n is the total number of observations and $\alpha = 0.95$. By doing this the $\text{VaR}_{0.95}^{DL}(r) = -0.0071$ which means that with 95% certainty the return will not be lower than -0.0071.

5.2 Result analysis for the daily long trading strategy

For the daily long strategy the winning percentage it not very high. This is due to how the strategy is built. The strategy should react when there has been a dip but it is impossible to say if the trade will be a losing trade or a winning trade at the entrance. The difference between the trades that are losing and those which are winning trades are that, on average, a winning trade's profit is more than twice the size of a losing trade's loss. This will in the end lead to a net profit.

As mentioned already in the previous section the winning trades are active during a longer time period than the losing trades. This is due to the fact that the strategy is designed to cut the losses short. The reason for cutting the losses short is to, if a trade already is losing, minimize the loss or at least to bound the loss. The statement of cutting the losses short is something that is well-known for traders. Especially if one is day trading without any algorithmic trading strategy it is important to cut the losses short and not hold on to a losing stock. That is the reason to exit a trade if the it starts to generate a loss.

The fact that the trade is over all earning money can also be seen when studying the expectancy, E. The expectancy for winning is $E_{winning} = 1.4$ and for losing it is $E_{losing} = -0.7$. If these two values are compared one can see that the winning expectancy is twice the size of the absolute value of losing expectancy, the profit are much bigger than the losses. Since the winning percentage also is bigger than 50% it will give the strategy net profit.

The histogram for return in the previous section shows a distribution that have a quite long tail on the negative side but despite this the $\text{VaR}_{0.95}^{DL}(r) = -0.0071$. This means that the risk of losing big amounts is not very large. One thing to be aware of with the VaR is that it says nothing about how big the largest losses are. There can still appear greater losses that have a return smaller than -0.0071.

Overall the risk of losing is decaying as the losses grow bigger. The chance of winning a big amount in one trade is decaying at a slower rate than the risk of losing.

The daily long strategy is compared to the buy and hold strategy as a reference. The buy and hold strategy is the strategy where one buys a contract at the same time as the daily long strategy and then hold it until one decides to stop. Below is the profit chart and a histogram of the returns for the buy and hold strategy.

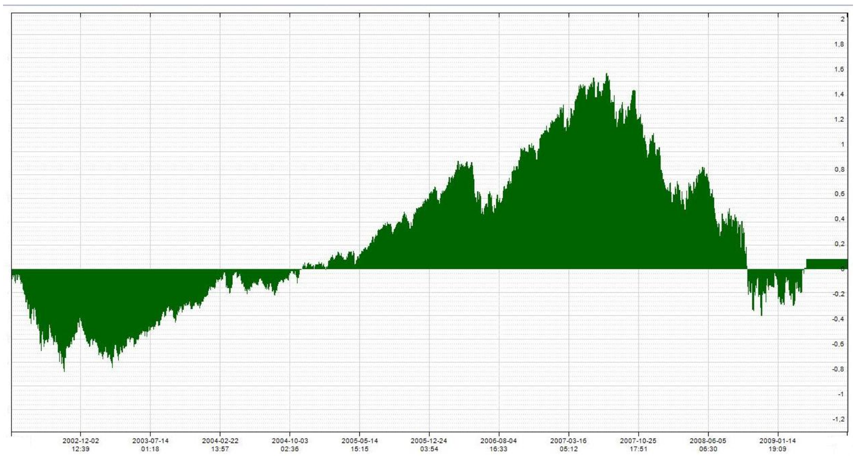

Figure 5.7: The profit chart for the buy and hold strategy.

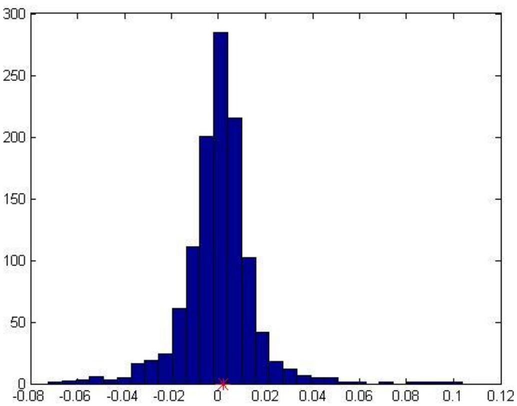

Figure 5.8: The histogram for the return each day when using a buy and hold strategy. The star shows the mean return in the daily long strategy.

If a comparison is made between figure 5.5 and figure 5.7 one can clearly see that the daily long trading strategy has a more satisfying behaviour. The buy and hold strategy follows the index movements which means at certain points it can loose what has been gained earlier. The daily long trading strategy has different types of stops that will prevent the strategy from losing as much as the buy and hold strategy. This gives the daily long strategy a more preferable profit chart as seen in figure 5.5.

The mean return for the buy and hold strategy, m_r^{BH}, is also just above zero as for the daily long strategy. The standard deviation is $\sigma_r^{BH} = 0.0153$ and the $\mathrm{VaR}_{0.95}(r)^{BH} = -0.0249$. The standard deviation is about ten times bigger for this strategy than for the daily long strategy, this shows that the buy and hold strategy has much bigger fluctuations in the return. The VaR for the return is also much smaller for this strategy. This indicates that the buy and hold is not to be preferred if one chooses between that strategy and the daily long strategy.

To have something more to compare to, the daily long trading strategy is also compared to a "simpler" strategy. This "simpler" strategy buys a contract if the prices jump up more than five points from day i to day $i + 1$ and it will sell the contract when at least 11 trading days have passed. The reason for choosing 11 trading days is that it was the average number of days for each trade in the daily long trading strategy.

The profit chart and a histogram of the return for the "simpler" strategy are presented below.

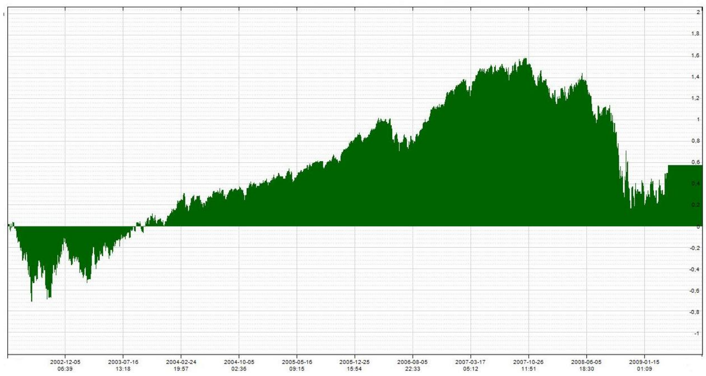

Figure 5.9: The profit chart for the "simpler" strategy.

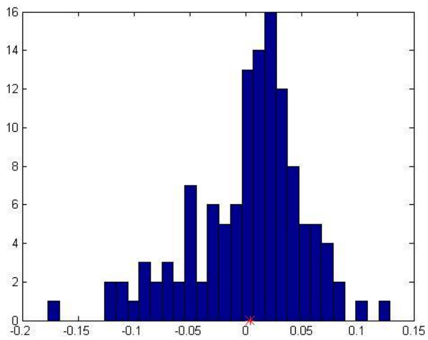

Figure 5.10: The histogram of the return for the "simpler" strategy. The start shows the mean return in the daily long strategy.

If one compares this profit chart, figure 5.9, to the profit chart in figure 5.5 and figure 5.7 one can see that this strategy is better than the buy and hold strategy to preserve the gains but not as good as the daily long strategy. This is to be expected since the "simpler" strategy does not have any profit targets to help the strategy to preserve some of the gains or stops to help minimizing the losses. Therefore the daily long strategy is better and safer than both the buy and hold strategy and the "simpler" strategy.

From the histogram the mean value for the return, m_r^S, the standard deviation for the return, σ_r^S, and the $\text{VaR}_{0.95}^S(r)$ were found for the "simpler" strategy. The mean value for the return was $m_r^S = 0.0020$ and the standard deviation $\sigma_r^S = 0.051$. The mean value for the return is a little bit higher for this strategy compared to the previous ones. The standard deviation is larger for this strategy than for the buy and hold strategy and the daily long strategy. The standard deviation shows that the return for this strategy fluctuates the most, which indicates that the size of the return can be in a large interval. The $\text{VaR}_{0.95}^S(r) = -0.091$ which is the smallest value so far, so this "simple" strategy is the worst strategy of these three strategies to invest money in.

The daily strategy is also tested for its robustness. It is important to see how the system reacts in different market scenarios. This study is done by simulating different market movements and then see how the strategy reacts in these different scenarios. The simulation is done 100 times and from that the mean return for a trade, $m_{r_{Rob}}^{DL}$, the standard deviation of the return per trade, $\sigma_{r_{Rob}}^{DL}$, and the $\text{VaR}_{0.95}^{DL}(r_{Rob})$ are estimated. Below is a histogram of the return from the simulation.

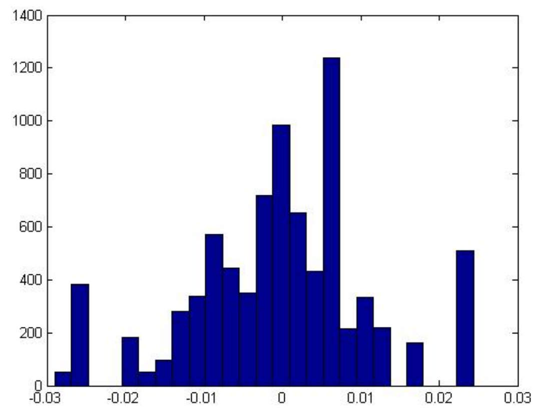

Figure 5.11: The histogram of the return in the robustness study.

The mean return, $m^{DL}_{r_{Rob}}$, was very close to zero and the standard deviation was $\sigma^{DL}_{r_{Rob}} = 0.012$. This simulation showed that on average the return in each trade is small but positive. This indicates that the strategy is quite robust, because even though many simulations were done the mean outcome was still positive. The estimation of the VaR was done by historical simulation and the $\text{VaR}^{DL}_{0.95}(r_{Rob}) = -0.029$. This value shows that with the certitude of 95% the return will not be lower than -0.029.

The conclusions to be drawn from this study are that the strategy handles with different market scenarios in an acceptable way. These results show that the daily long trading strategy is working in different market scenarios even though the strategy was not designed for those scenarios to begin with. The strategy does not generate as big profit as in the real study, but the results are still acceptable.

5.3 Results for the daily short selling strategy

This strategy is built to be active when the market is going down, hence in a bear market. By studying the plot below one can see that this is exactly what the strategy does.

Figure 5.12: The chart for the daily short selling strategy with trades marked.

This strategy has a winning percentage just above 50%, or more exactly 52.9%. This is based on that the strategy has made 34 trades of which 18 where winning trades and 16 losing trades.

On average each trade was 9 trading days long. If separated into winning and losing trades, the winning trades were 14 bars long and the losing trades were about 3 bars long. This is also a result of the fact that losses wants to be cut short.

The profit is on average for each trade 22.2 points or in per cent 2.9%. If once again the profits and losses are separated the profits is on average 61.7 points. The losses are 22.3 points.

This gives that the total gain of the strategy is about 750 points or in per cent the wealth has increased by 98.6%.

Below is the profit chart for the strategy when all time is included.

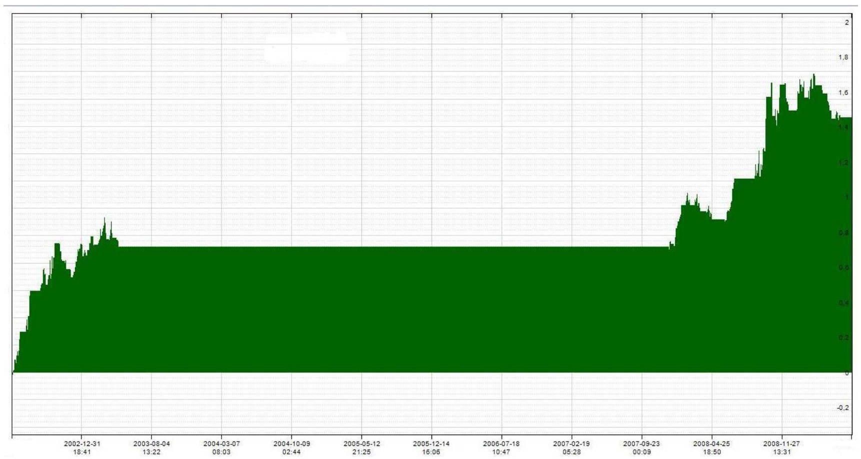

Figure 5.13: The profit chart for the short selling daily strategy between November 2002 to May 2009.

Here is the profit chart when the time not in trades is excluded.

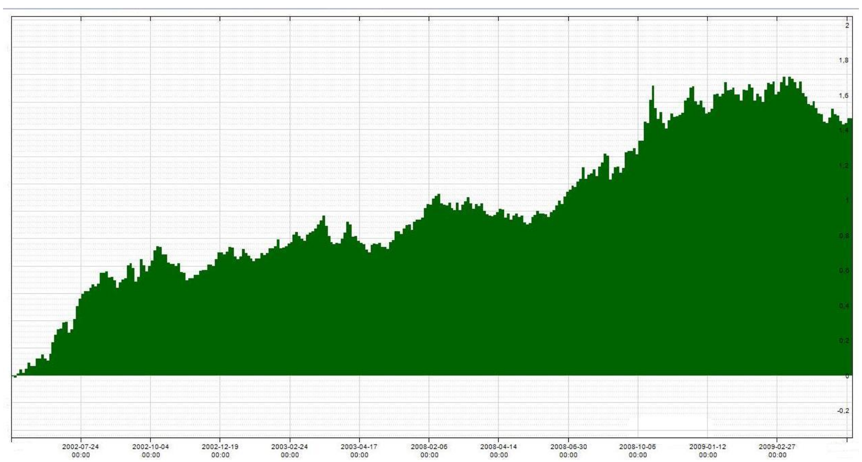

Figure 5.14: The profit chart for the short selling daily strategy only when time in trades are included.

The expectancy, E, is also measure here and is $E = 0.34$. For the losses the expectancy is $E_{losing} = 0.29$ and for the trade won $E_{winning} = 0.89$.

The value of maximal draw down is about 121 points or in per cent 17.4%. As the risk adjusted return is based on this value, $RAR = 6.0$. The pay-off ratio is about 2.8, this means as above that the value of the profit is 2.8 times larger than the losses.

A histogram of the arithmetic return, defined in section 5.1, for this strategy looks as below.

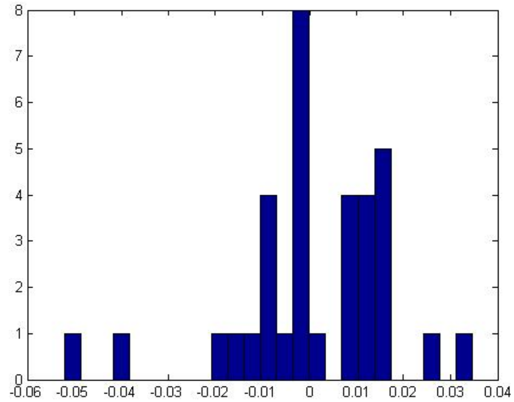

Figure 5.15: A histogram for the return for the daily short selling strategy.

As one can see in the histogram the main peak is around zero. The mean value for the return, m_r^{DS} is at $m_r^{DS} = 0.0011$ and the standard deviation for the return in this strategy $\sigma_r^{DS} = 0.0166$. If one calculates the empirical VaR for the return r, in the same way as for the daily long strategy, the $\text{VaR}_{0.95}^{DS}(r) = -0.04$. This means that at with a certainty of 95% the return will not be below -0.04.

5.4 Result analysis for the the daily short selling strategy

This strategy has an lower winning percentage than the long strategy, it is just above 50%. This is once again due to how the strategy is built. The difference between this strategy and the long trading strategy is that here will the profits run even further. This yields, on average, that the profits are about three times bigger than the losses.

Since the losses are small in relation to the profits this gives a quite large net profit even though the winning percentage is just above 50%.

The expectancy is once again larger for a winning trade than for a losing trade. The reason here is the same as explained earlier, in section 5.2.

For the the long and short strategy based on daily data the risk-adjusted return, *RAR*, is almost the same. This means when taking into account the risk for both these strategies are almost equal in its performance. The long trading strategy is even a little bit better than the short selling strategy. The reason for this is, even though the short selling strategy yields a much bigger profit, that the long trading strategy is active when the volatility is lower. The short selling strategy is active when there is a bear market. In a bear market the volatility tends to be higher than in a upwards trending market. This is the reason for the the risk-adjusted return is lower for the short selling daily strategy than for the daily long trading strategy even though the net profit is much larger for the short strategy.

The $\mathrm{VaR}^{DS}_{0.95}(r) = -0.04$ indicates that in 95% of the cases the return will be bigger than -0.04. This value for the VaR is smaller than for the long strategy. When the market is going done it often is higher volatility which means that the profits made can be lost quite fast. This is the reason for the smaller VaR value.

This strategy is compared to the buy and hold strategy. As for the long trading strategy the profit chart for short strategy, figure 5.14 has a nicer behaviour than the profit chart for the buy and hold strategy, figure 5.7. The short strategy has both profit targets and different types of stops to help the strategy lock in profits and to prevent big losses. The buy and hold strategy has nothing to protect it from big leaps, it just follows the index. This is the reason for that the profit chart of the daily short strategy has a more linear behaviour than the profit chart for the buy and hold strategy. When comparing the values for the return in the daily short selling strategy and the buy and hold strategy one sees that the mean return is greater for the daily short selling strategy since the buy and hold strategy had a mean close to zero. The standard deviation, in the buy and hold strategy, is in the same magnitude as for the daily short strategy. The $\mathrm{VaR}^{BH}_{0.95}(r) = -0.025$ for this strategy, which is bigger than for the daily short selling strategy. The difference is not very large and is harder to say in this case which one of these to strategies that is to be preferred if one had to choose.

A "simpler" strategy that is short selling is also implemented to have something more to compare with. The "simpler" strategy is shorting a contract if the market goes down 5 points from day i to day $i+1$. When the trade has been active more than 9 days the strategy tries to exit the trade as soon as possible. The reason for choosing 9 days is that 9 days is the average length of a trade using the daily short selling strategy. If the "simpler" strategy is used during the same time period as the daily short strategy, the profit chart and the histogram of the return for the "simpler" strategy look like below.

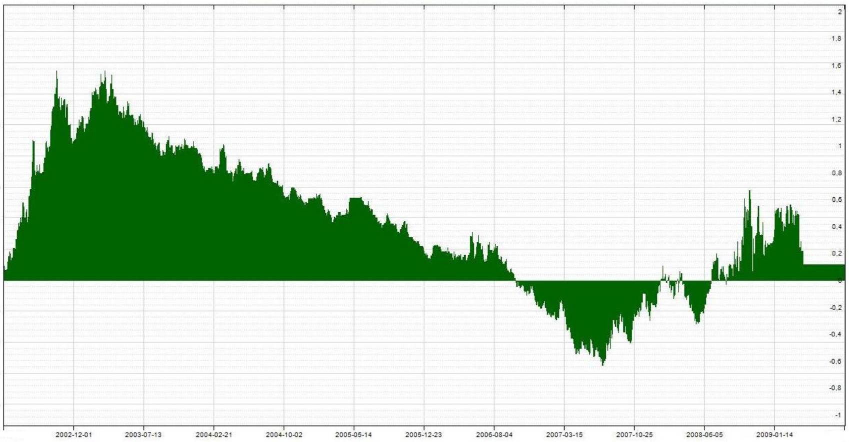

Figure 5.16: The profit chart for the "simpler" short selling strategy.

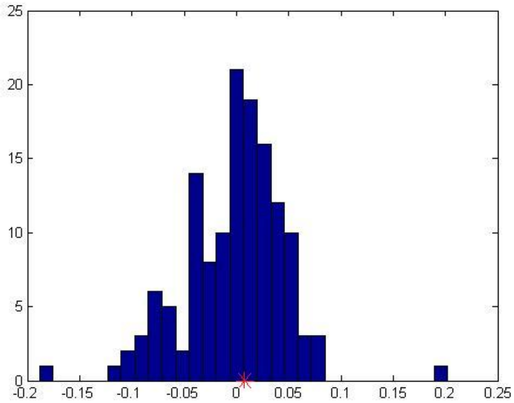

Figure 5.17: The histogram of the return for the "simpler" short selling strategy. The star show where the mean return in the daily short selling strategy is.

If a comparison is made between the profit chart for the daily short selling strategy, figure 5.14, and the profit chart of this the "simpler" strategy, figure 5.16, it is easy to see which one is the most beneficial. The "simpler" strategy has no targets that will help it lock in profit or prevent losing. The mean value of the return, m_r^S for this "simpler" strategy is $m_r^S = 0.0016$. This is the smallest value if one compares the daily short selling strategy, the buy and hold strategy and this the "simpler" strategy. The standard deviation, σ_r^S is also the largest of these three strategies, it is $\sigma_r^S = 0.048$. The VaR for this strategy is $\text{VaR}_{0.95}^S(r) = -0.084$. This VaR value is small which indicates that this strategy have large negative returns quite often.

The daily short strategy is to be preferred if a choice between these two strategies are to be made.

The robustness for this strategy is studied in the same way as for the daily long trading strategy. Below is the histogram over the return in all the different scenarios simulated.

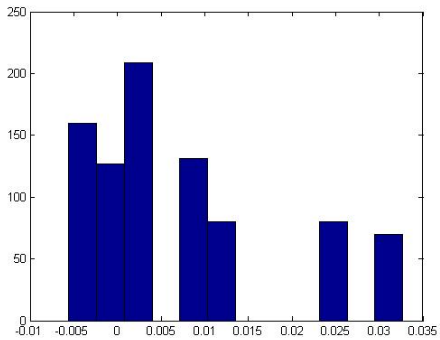

Figure 5.18: The histogram of the return for the robustness study.

The mean return, in this case, was $m^{DS}_{r_{Rob}} = 0.0071$ and the standard deviation was $\sigma^{DS}_{r_{Rob}} = 0.011$. The mean return and the standard deviation are in the same magnitude as the mean return and the standard deviation in the real study. This is a good sign which indicates that the strategy acts in a similar way with the simulated data as with the real data. $\text{VaR}^{DS}_{0.95}(r_{Rob}) = -0.0056$ which shows that the return will not be lower than -0.0056 in 95% of the cases. This VaR value is bigger, if compared to the robustness study for daily long strategy which indicates that the returns are bigger in this case than for the daily long trading strategy.

If one compare this values in the robustness study to the values in real study one can see that these values are of the same magnitude. One can see that the VaR value in the robustness is larger than in the real study. This indicates that the results from the robustness study is comparable to the real results, and the strategy can be said to be robust.

5.5 Results for the long strategy based on five minute data

This five minute long strategy has a winning percent of 47.5% when a total of 484 trades has been made. When examining the plot in detail one can see that the strategy works whenever there is a up going movement in the index. The average number of bars for a trade is 92 bars. For a losing trade the number of bars is in average 78 bars but for a winning trade the number of bars are 108 bars.

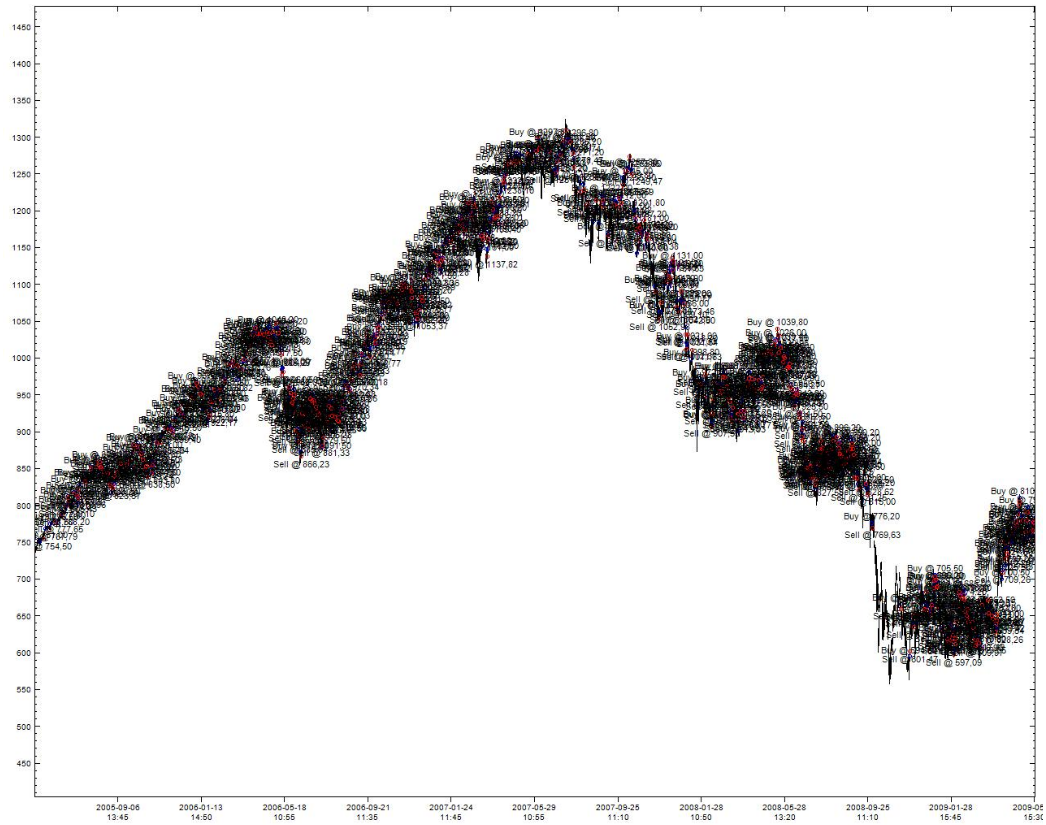

Figure 5.19: The chart for the five minute long trading strategy with trades marked.

On average each trade generates 1.75 points of profit. If the winning trades and the losing trades are separated it is noticed that the average loss for a losing trade is about 7.0 points but for a winning trade the average profit is about 11.4 points. Hence once again the expected pattern is recognized.

This strategy yields in total a profit of 849 points or expressed in per cent 93.6% more than what originally was bought for. The expectancy, E, defined earlier is $E = 0.0019$. For a winning trade the expectancy is $E_{winning} = 0.012$ and for a losing trade the expectancy is $E_{losing} = -0.0074$.

The profit chart for this long strategy based on five minute data, with all time included.

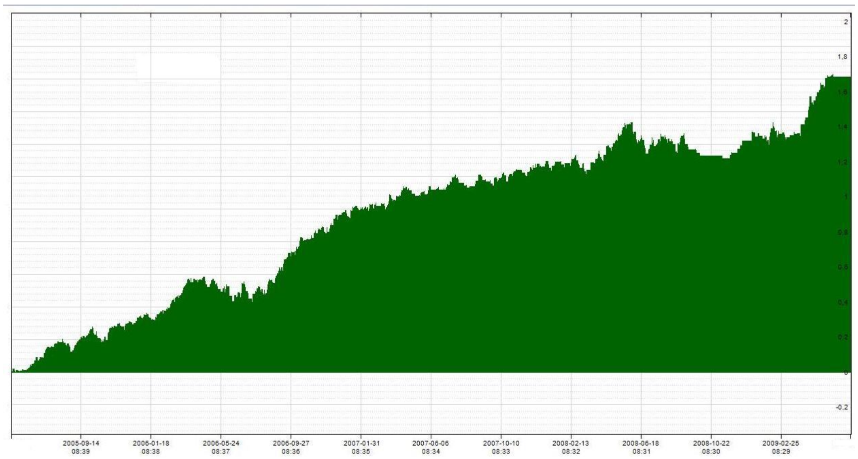

Figure 5.20: The profit chart for the long trading five minute based strategy between November 2002 to May 2009.

The profit chart with the time not in trades excluded.

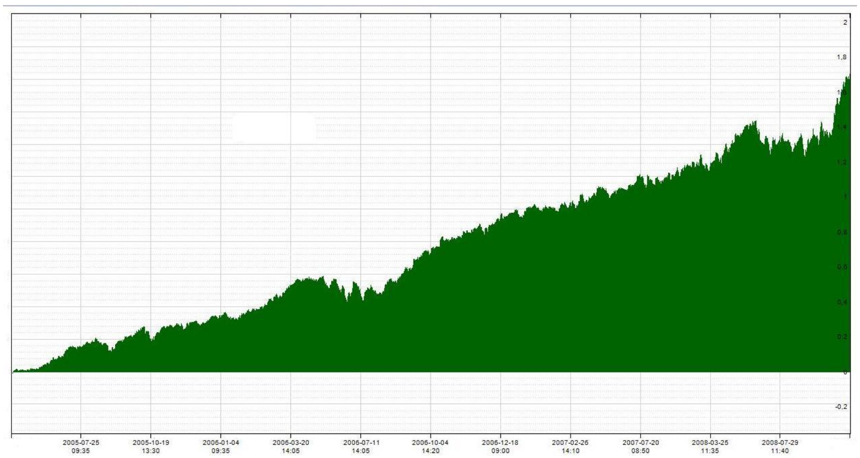

Figure 5.21: The profit chart for the long trading five minute based strategy only including the actual trading time.

The maximum draw down is about 113 points, in per cent the maximum draw down is 11.8%. The pay-off ratio is 1.6 this means that a profit is about 1.6 times larger than a loss.

The factor that takes in to account some risk is the risk adjusted return, RAR, defined earlier. For this strategy the risk adjusted return is $RAR = 7.7\%$ and instead expressed in points it is 7.3 points.

Below is the histogram of the arithmetic return, r, for this strategy.

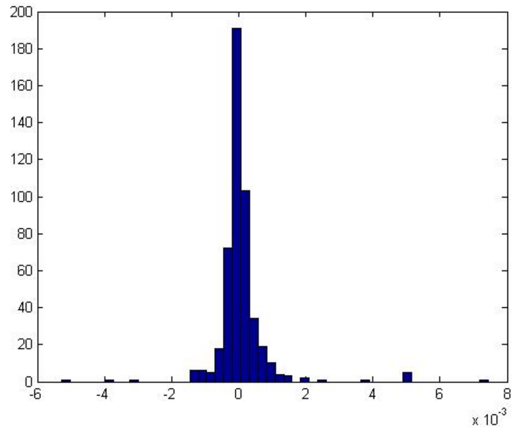

Figure 5.22: Histogram for the arithmetic return, r, for the five minute long strategy.

The mean value for the arithmetic return is $m_r^{ML} = 7.9 \cdot 10^{-5}$ and the standard deviation $\sigma_r^{ML} = 8.3 \cdot 10^{-4}$. From the values for the return r, the empirical $\text{VaR}_{0.95}^{ML}(r)$ is calculated. The $\text{VaR}_{0.95}^{ML}(r) = -6 \cdot 10^{-4}$. This means that in 95% of the cases the return, r, will not be below $-6 \cdot 10^{-4}$.

5.6 Result analysis for the five minute long trading strategy

The winning percentage is for this strategy below 50%. But even though there are more losses than wins the net profit is quite large. This is due to the fact that, on average, each winning trade is larger than each losing trade.

An other thing noticed is that the expectancy, E, is small. The reason for this is that there are more losses than profits for this strategy during its active time. The overall expectancy is larger than zero. This means that even though there are fewer winning trades than losing ones the profits compensate the losses and an over all net profit is made.

The risk-adjusted return, RAR, for this strategy is about 7.7% which is higher than for the both of the daily trading strategies. Since the RAR is quite high the strategy is worth using even though the winning percentage is low.

As seen in figure 5.19 the strategy trades not only when the general movement of the index is up going but also when the index's general movement is moving down. The reason for this is that it was hard two find a strategy with good results that will trade only when the market is moving up, based on five minute data. This strategy will therefore try to catch the small up going movements in a down trending market. Since the winning percentage of the strategy only is about 47.5%, the strategy can probably be modified a bit to get a better winning percentage.

In comparison with the daily strategies the VaR is larger for this five minute based long trading strategy. The VaR is larger which means that with 95% certainty the return will not be lower than $-6 \cdot 10^{-4}$. But on the other hand the actual profits made in each trade are much smaller, measured in points, when comparing to the daily strategies.

If instead a buy and hold strategy is used during the same time as the five minute long trading strategy the profit chart looks like below.

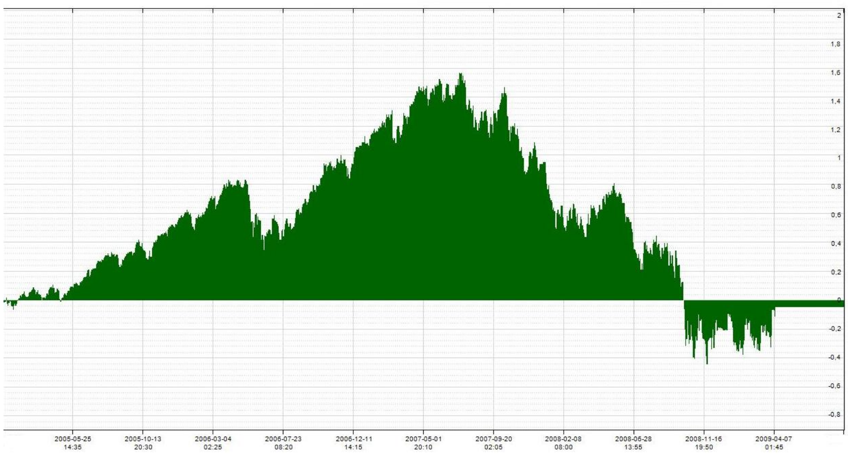

Figure 5.23: The profit chart for the buy and hold strategy based on five minute data.

It shows that the profit gained for the five minute strategy is safer than the profit gained in the buy and hold strategy. This is due to the fact that in the buy and hold strategy only one trade is made. For the five minute strategy many trades are made and this makes the profit locked in better. The buy and hold strategy has no security at all in the sense of locking in profits or minimizing losses since the buy and hold strategy only follows the index.

The buy and hold strategy is also very dependent on where the entrance is made but in the long run the buy and hold will behave worse than the five minute long trading strategy since it does not have a safety net that will prevent big losses. As one can see in the profit chart for the buy and hold strategy the gain in the beginning is quite vast but when the market turns the buy and hold strategy can not do anything to prevent a big loss.

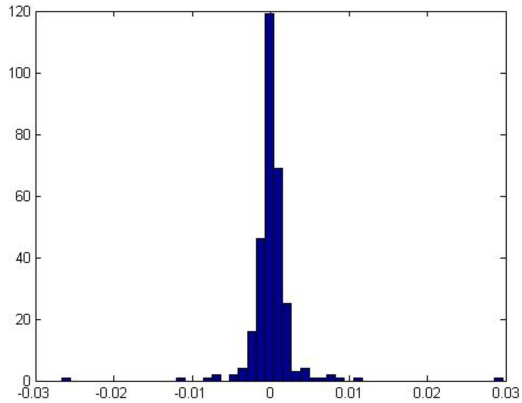

Figure 5.24: The histogram of the return for the buy and hold strategy based on five minute data.

In the histogram of the return one can see that the mean return is close to zero, it is $m_r^{BH} = 1.07 \cdot 10^{-4}$. This mean return is larger than for the five minute long trading strategy but still it is small. The standard deviation for the return is $\sigma_r^{BH} = 0.0031$ and the $\text{VaR}_{0.95}^{BH}(r) = -0.0024$. If one compare these three values to the short selling strategy based on five minute data the following conclusion can be drawn. The standard deviation is higher in the buy and hold strategy and VaR value is smaller. This makes the return of this strategy to fluctuate more than for the long trading five minute strategy. If the VaR value for the buy and hold strategy and the five minute long trading strategy are compared one sees that the VaR value for the buy and hold strategy is smaller. This indicates that the returns can be smaller for the buy and hold strategy, since one would want as large VaR as possible. Based on these analysis the five minute long trading strategy would to be preferred, if a choice between the two strategies was needed.

As an other reference a "simpler" long trading strategy than the five minute long strategy is tested. This "simpler" strategy is buying a contract when the index has moved up 2 points from day i to day $i + 1$. It is exiting a trade as soon as possible after 460 minutes. The average trade length was 460 minutes for the five minute short strategy which is the reason for using this as an exit signal. The profit chart for this strategy can be seen below.

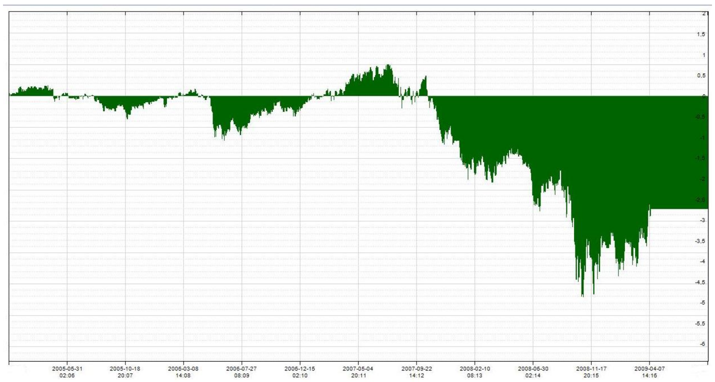

Figure 5.25: The profit chart for the "simpler" long trading strategy based on five minute data.

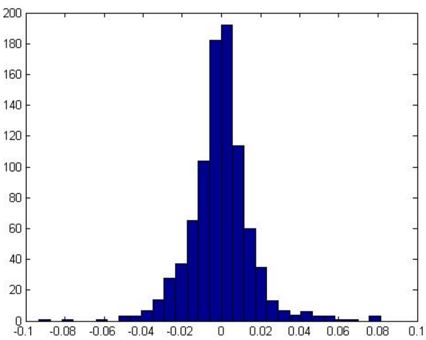

Figure 5.26: The histogram for the arithmetic return "simpler" long trading strategy based on five minute data.

The mean value of the return for this the "simpler" strategy is $m_r^S = -4.2 \cdot 10^{-4}$. The mean value of the return is larger than for the five minute long trading strategy but still it is close to zero.The standard deviation is $\sigma_r^S = 0.016$ which to be compared to the standard deviation for the five minute long trading strategy which is about twenty times smaller than the standard deviation for this the "simpler" strategy. This shows that the return in the "simpler" strategy is very fluctuative and a positive return is not at all to be expected. The $\text{VaR}_{0.95}^S(r) = -0.026$ which compared to the five minute long trading strategy is a worse value which indicates that in 95% of the cases the return will not be lower than this value.

The behaviour of this "simpler" strategy is even worse than for the buy and hold strategy, when studying the profit charts, compare figure 5.21, 5.23 and 5.25. When a comparison is made with the five minute long strategy it is obvious that the five minute long trading strategy is the best choice. The profit chart in figure 5.21 is showing a much nicer behaviour than the profit charts in figures 5.23 and 5.25. The reason for the more preferable behaviour is that the five minute long trading strategy locks in profits and tries in the best way possible to minimize losses. Neither the buy and hold strategy nor the "simpler" strategy has these properties which make them much more sensitive to index movements.

The long trading five minute based strategy has also been tested for its robustness. This is done by simulation index movements 100 times and then calculating the mean return, $m^{ML}_{r_{Rob}}$, the standard deviation for the return, $\sigma^{ML}_{r_{Rob}}$, and the VaR for the return, $\text{VaR}^{ML}_{0.95}(r_{Rob})$. Below is the histogram of the return derived from the simulation.

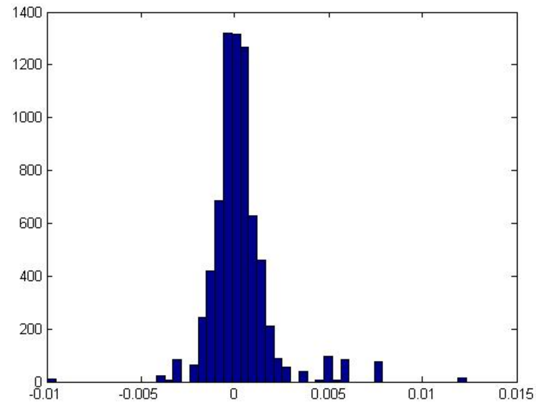

Figure 5.27: The histogram of the return for long trading strategy based on five minute data,derived from simulations.

The mean return for each trade, $m^{ML}_{r_{Rob}} = 2.8 \cdot 10^{-4}$ and the standard deviation $\sigma^{ML}_{r_{Rob}} = 0.0017$. These values are larger than the values from the real study, but the difference is not too large, the results are still comparable. $\text{VaR}^{ML}_{0.95}(r_{Rob}) = -0.0027$, which means that the return will no be lower than -0.0027 in 95% of the cases. This VaR value is an acceptable value if one compare it to the VaR value of the real study. To sum up, the results from this robustness study are not the greatest but they are at least as good to be accepted and the strategy can be said to be robust.

5.7 Results for the short selling strategy based on five minute data

In this strategy a total of 114 trades have been made during the specific time period the strategy was tested. Of the 114 trades 80 trades generated a profit and 34 trades generated a loss. This gives a winning percentage of about 70%.

On average the a winning trade is 136 bars long and a losing trade is 226 bars long. This gives that a trade is about 163 bars long. This behaviour is something that not have been seen before, that the losing trades contains more bars than the winning trades.

The winning trades yields on average a profit of 18.5 points or in per cent 1.9%. A losing trades looses in points 26.7 points. On average this gives for each trade a gain of 5.0 points. Below is the plot of the index's movement with the trade marked as well.

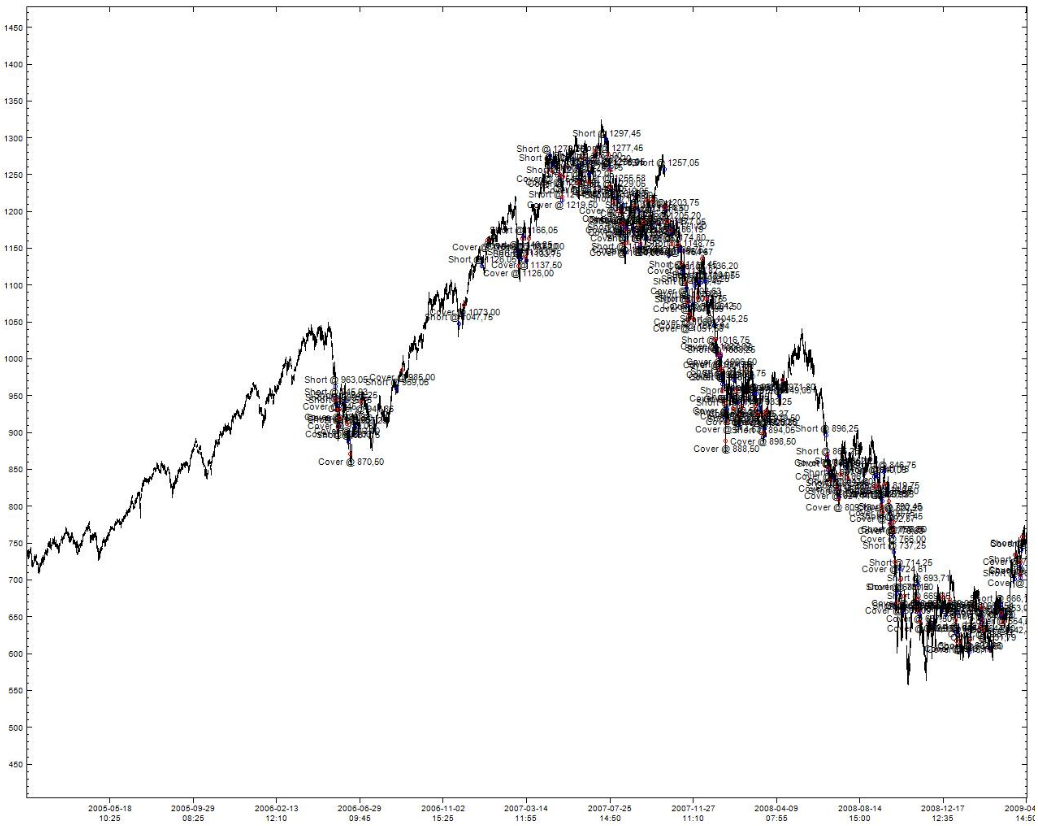

Figure 5.28: The chart for the short selling five minute based strategy with trades marked.

The total gain for this strategy is 567 points or expressed in per cent 56.7%. This means that the capital is 56.7% larger than it was when the money was invested.

Below is the profit chart for this strategy.

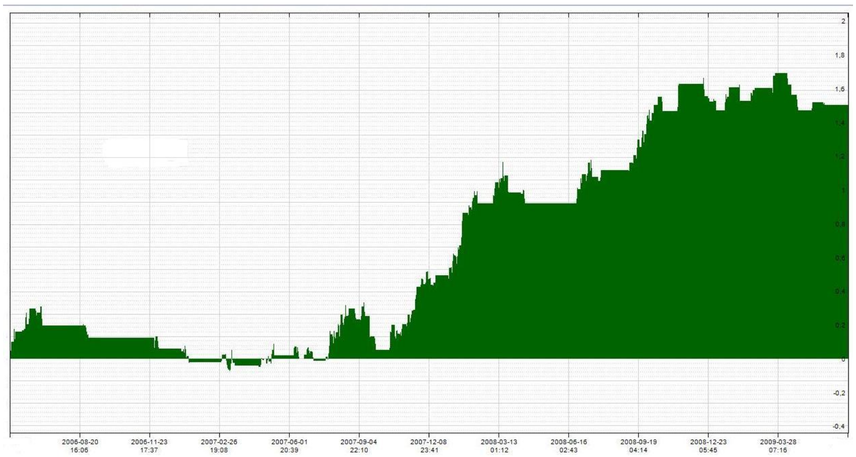

Figure 5.29: The profit chart for the short selling five minute based strategy.

And the profit chart when only the trading time is included.

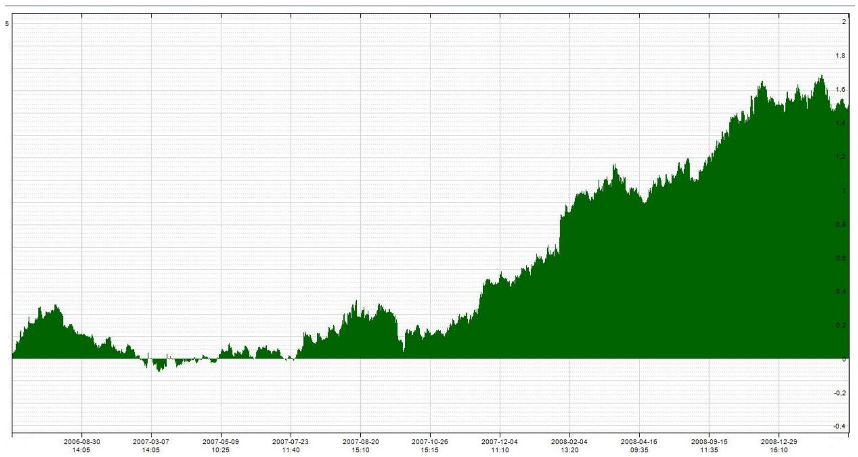

Figure 5.30: The profit chart for the short selling five minute based strategy.

The expectancy, E, for this strategy is $E = 0.099$. If separated in to winning and losing trades the following is seen that a losing trade has the expectancy of $E_{losing} = -0.56$ and a winning trade has the expectancy of $E_{winning} = 0.38$.

The maximum draw down for this strategy is about 160 points or in per cent 15.8%. The pay-off ratio is 0.68 which mean that a winning trade is only about two thirds as big as a losing trade.

The risk adjusted return, RAR, is for this strategy 3.5 points and in per cent 3.6%.

The Value at Risk for the return, $\mathrm{VaR}_{0.95}^{MS}(r)$, is also calculated for this strategy. First the arithmetic return, is calculated as in previous sections. It follows a histogram of the return, r, below.

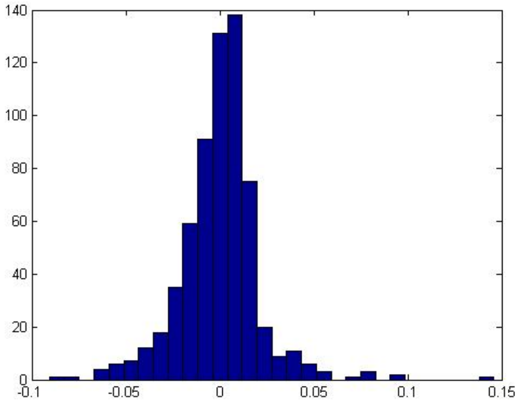

Figure 5.31: The histogram for arithmetic return, r, for the five minute short selling strategy.

The mean value for the arithmetic return is $m_r^{MS} = -1.9 \cdot 10^{-4}$ and the standard deviation is $\sigma_r^{MS} = 4.8 \cdot 10^{-4}$. The VaR is calculated by using empirical estimation at a level of 95%. When this is done the $\mathrm{VaR}_{0.95}^{MS}(r) = -0.0011$.

5.8 Result analysis for the five minute short selling strategy

The winning percentage for this five minute short selling strategy is the highest of all the strategies. It is about 70% which is a much better result when comparing to the other strategies. This makes this strategy quite often to end up with a profit since seven trades out of ten will have a positive outcome.

This strategy gives a different result than all the other strategies when comparing the length of the winning and losing strategies. Here the losing strategies are much longer than the winning strategies. The reason for this is that for this five minute short selling strategy most of the trading is done in a bear market. In the bear market the volatility is higher than in a bull market. When trading in a bear market, especially when the strategy is based on five minute data, the strategy can not be so sensitive to fluctuation. It has been seen that to be able to get a net profit the strategy must be able to allow much bigger fluctuations than the five minute based long trading strategy. This is the reason for that the losing trades are much longer than the winning trades.

As seen the losses are also bigger than the profits, on average. But since the winning percentage is over 70% the strategy yields in total a profit. Since the losses are bigger than the profit the expectancy for losing trades are bigger than the one for winning trades. The expectancy for all the trades are positive, this is due to the fact that the there is a lot more profitable trades than there are unprofitable trade.

The risk-adjusted return, *RAR*, for this strategy is only about 3.5%. The reason for thesis that the strategy is active during a downwards trending market. When the market is trending downwards the volatility, in general, is higher than for a upwards trending market. For this strategy as well the actual profit for each trade is not as high as for the other strategies. These are the reasons for the low *RAR* value.

When studying the profit chart one can see that a straight line is not a good approximation of the profit chart. The worst behaviour is seen in the beginning of the profit chart. This behaviour comes from the fact that when studying the index's movement there is a quite large dip in in the index's movement but then the index's starts to go up again. The strategy reacts on this dip but when the index starts to move up again the profit one hoped for is lost. When the general movement is going down the strategy is reacting and more profit is made.

The Value at Risk, VaR, for this short selling strategy is ones again more negative than the VaR for the long strategy. The reason for this is once again that the volatility is higher when the strategy is selling short than it is when the strategy is buying long.

If the buy and hold strategy, figure 5.23, is compared to with this short selling strategy, figure 5.30, one can see that in the beginning the buy and hold strategy is gaining quite a lot, but as for the five minute short selling strategy nothing much is earned. After a while the buy and hold strategy starts to loose what have been gained while the five minute short selling strategy starts to be profitable. Thus in the end the five minute short selling strategy has made more profit than the buy and hold strategy.

When studying the profit chart in figure 5.30 one sees that in the beginning the profits is fluctuation around zero. This means that the index is moving in a non-preferred direction, but even though this is happening, the strategy controls the losses and there are no big losses. This is one of the advantages of the five minute short selling strategy.

As for all the other strategies a comparison with a "simpler" strategy is also made. It behaves in a similar way as all the other "simpler" strategies has done. The strategy is short selling when a 2 points down move has been made from day i to day $i + 1$ and is exiting the trade when its been active longer than 810 minutes. 810 minutes is chosen from the fact that the average length of a trade in the five minute short selling strategy is about that long. The profit chart and the histogram of the return for this "simpler" strategy are below.

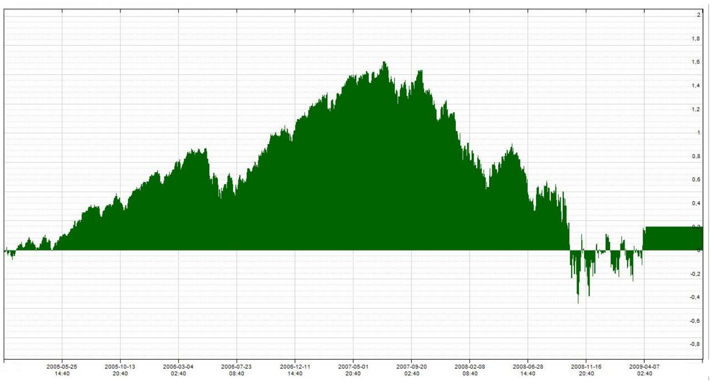

Figure 5.32: The profit chart for the "simpler" short selling five minute based strategy.

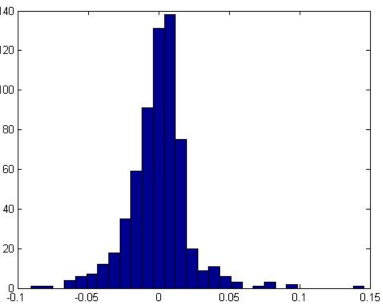

Figure 5.33: The return for the "simpler" short selling five minute based strategy.

The mean value of the return for this "simpler" strategy is $m_r^S = 1.1 \cdot 10^{-4}$ and the standard deviation is $\sigma_r^S = 0.021$. The mean value for this strategy is higher than for the five minute sort selling strategy, but the standard deviation is much higher, which causes the return to fluctuate much more. The $\text{VaR}_{0.95}^S(r) = -0.035$ for the "simpler" strategy which is a lower value than for the five minute short selling strategy. Comparing the standard deviation and the VaR, for this strategy, with those values for the five minute short selling strategy indicate that the best performing strategy between those two is the five minute short selling strategy.

As seen in the figure 5.32 quite a lot of profit is made in the beginning but the more is lost when the market has turn in a non-preferred direction. This is typical for the "simpler" strategies, they works well when the market is moving in the right direction but when it changes the "simpler" strategies have no chance of saving some of the profit already made.

The robustness for this strategy is also studied, in the same way as for the long trading five minute based strategy. It means that a simulation of the index movement was done 100 times and then estimations of the mean return, $m_{r_{Rob}}^{MS}$, the standard deviation of the return, $\sigma_{r_{Rob}}^{MS}$, and the $\text{VaR}_{0.95}^{MS}(r_{Rob})$ were performed. Below is the histogram of the profit derived from the simulations.

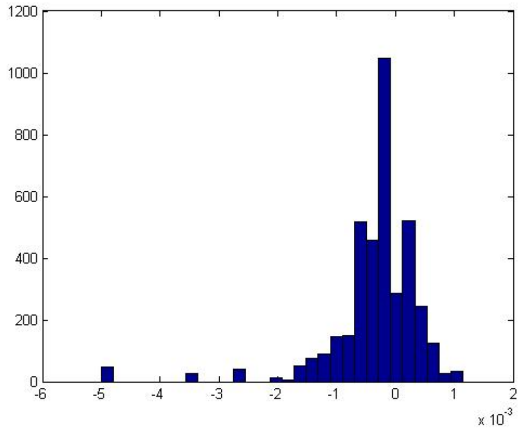

Figure 5.34: The histogram of the return for short selling five minute based strategy, when doing simulations.

The mean return for each trade $m_{r_{Rob}}^{MS} = -3.4 \cdot 10^{-4}$ and the standard deviation $\sigma_{r_{Rob}}^{MS} = 8.0 \cdot 10^{-4}$. The mean return for this strategy is of the same magnitude as the mean return in the study based on real data, the same is true for the standard deviation. The $\text{VaR}_{0.95}^{MS}(r_{Rob}) = -0.0015$, if one compare this to the mean return given from the real data set one can see that the difference is small. If one compare the results from the simulations with the result based on the real data set one can see that the difference is small. This indicates that the strategy is acting in an acceptable way and the strategy is robust.

Chapter 6

Conclusions

The first and most important conclusions drawn from trying to create algorithmic trading strategies is that the is hard to find a way of generally describing the movements on the market. There is always some behaviour that will occur that the strategy has not been designed to deal with. The most important thing to have is thus good profit targets and good stops. When being more specific the stops is the absolute most important thing to have to prevent losing a lot of money if the market is turning without giving the expected signals for the strategies to react on.

An other thing noticed when trying to build these strategies are that when one succeeds to get quite a large profit for a strategy the winning percentage becomes lower and also the other way around when the winning percentage is rising often the profit is falling. The reason for this is that to increase the winning percentage for the strategy the actual time each trade is active is shortened. When the time is shortened for each active trade the index will not have the time to move as much which leads to lower profit for each trade and in the long run lower profit totally.

The two strategies based on daily data are more stable when it comes to behaviour over time. These strategies have been tested on a longer time span than the five minute based strategies. The five minute strategies is very dependent on how the market has behaved. If the market changes in some way and becomes different from what it has been earlier the strategies may not work. This is true for all the strategies but probably the most sensitive strategies are the five minute based strategies.

A weakness of the strategies are that they are based on earlier data to try to find a way of earning money in the future. There is no guarantee that the market will behave in the same way as it has done before. The hopes are that the market in some sense will have the same behaviour and if it does these strategies will catch this behaviour and react if they find good signals.

Something else discovered is that there are many ways of trying to build strategies and they can very easy get complicated. The main focus when building these strategies was to try building them as simple as possible. When studying other algorithmic trading strategies that have work in the past it was seen that often there was no gain in building complicated models. That is the reason for trying to keep the model as uncomplicated as possible.

These strategies sometimes have values that can seem randomly taken but that is not the case. These values have been fixed when the strategies were tested on a specific data set used for backtesting. When the strategies showed good result for this separate data set they were tested on the real data set and showed acceptable result there as well. But these values are a limitation for the strategies since the values may work fine now, but if they will work in the future no one can tell, since no one knows how the market will look in the future.

The VaR is good measure in the sense that it is versatile and is a easy way of quantifying potential losses. But the Value at Risk have some disadvantages as it does not say anything about the biggest losses and can thus create a false sense of security. The Value at Risk does also not say anything about the positive results. It measures the bad nature of the strategies but does not say anything about how the strategies works as they are supposed to. This is something to keep in mind and to decide whether the strategies in whole are performing well other aspects than the Value at Risk must be considered as well.

Chapter 7

Improvements

There are a few things that can be improved and studied further. The first thing that comes up to mind is all the parameters with one distinct value. These values may be possible to improve further and boost the strategies and make them even better. An other improvement of these parameters is to give them different values based on other circumstances as for example the volatility. If this is possible the model may be able to perform better in intervals where the strategy now is under-performing.

An other improvement may be to have other conditions for when the trade should be entered. If one analyses the strategies even more one may be able to give better conditions for the to give the strategies even higher winning percentage. Especially for the strategy based on five minute data that is buying long contracts.

The strategy buying long contracts based on five minute data is the strategy that need to be studied the most due to the issue of the low winning percentage. As mentioned in the previous section the entering conditions for a trade can use a more detail study to make the strategy perform better. But the conditions for exiting a trade probably also could need an overview.

If one wants to develop the strategies more, one improvement could be to introduce scaling. If the strategies uses scaling one could scale in a trade of one thinks that the market will move in a preferable direction or scale out if the market moves in the wrong direction. If one uses this the loss could be smaller than it is now because some of the profit may be preserved. As for the scaling in the strategy could earn more if more contracts are entered when the market is moving in the direction that preferred for the strategy.

In general the strategies would probably be even more effective if the triggers and other factor are based on dynamic parameters instead of fixed values.

For example a quota of of different parameters could be used instead of a fixed value. This is not easy due to the fact that it is sometimes hard to know which parameters one should use in the quota.

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