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UNIVERSITEIT VAN AMSTERDAM

The Profitability of Candlestick Chart Patterns: A Study on The AEX-index

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Abstract

There are many methods traders use to predict stock prices. The purpose of this thesis is to test if simple Candlestick Chart Pattern strategies, Technical Analysis, can generate abnormal returns. The AEX-index in The Netherlands has been used for analysis. The data series examined in this thesis are the daily levels of the AEX-index. To my knowledge, this is the first thesis that examines a Candlestick Chart Pattern strategy on the AEX-index.

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1 Introduction

Professional and practitioner traders try to trade their way to have a steady income. Whether it is on a short- or long-term, they try to find the Holy Grail. Traders begin their day reading the Financial Times and keep an eye on CNN and Bloomberg during the day to be continuously updated about the financial market. They evaluate the market using fundamental analysis or/and technical analysis.

Fundamental analysis is a technique that attempts to predict the value of a firm. Fundamental analysis uses the underlying values of a firm and focuses on firm specific factors (e.g. dividend policy, leverage ratio etc) that have an effect on actual and future business-performance of the firm. The main purpose of investors is to determine if a firm is over- or undervalued. After the valuation is determined, an investor acts rationally on this situation by buying the firm's stock when it is undervalued and selling the stock when it is overvalued. One who uses this approach assumes that the market corrects the over- and undervaluation over time, and earns a profit due to this. In practice using fundamental analysis is difficult due to the complexity, coherent and the quantity of factors which affects the firm (e.g. macroeconomic factors, microeconomic factors, social factors and political factors). Due to the complexity of fundamental analysis one has to realize that the valuation could be wrong, thus could act wrong on the situation. Another method to predict the value of a firm is to calculate the sum of the discounted future cash flows of a firm. A downside of this approach is that the discount factors which are used to estimate the future cash flows are based on historical risk premiums and interest rates. In reality the discount factors could deviate from the real future values, which in the end results in wrong calculated future cash flows and a wrong estimated firm value. In general fundamental analysis is used for long term investments and technical analysis is used for short term investments (Park and Irwin, 2004).

Many examinations have been done on technical analysis the last century. During this period, significant and insignificant results have been identified. Technical analysis is an analysis of securities by using past prices, volumes and open interest (Park and Irwin, 2004). Technical analysis is based on the fact that history repeats itself and prices move in trends (Murphy, 1999). The main purpose of technical analysis is to detect a trend or trend reversal. Although detecting a trend is subjective, therefore one who undermines technical analysis finds that technical analysis is a self-fulfilling prophecy due to psychological factors which technicians have to bear with. Technical analysts have some advantages relative to

fundamental analysis. The main advantage is that technical analysis is cheaper and can be applied more easily on securities than fundamental analysis.

A negative aspect of technical analysis is that trading systems and parameters could be over-optimalized with respect to the data-set, due to misusing the parameters/data so that the result could reflect an unrealistic view. Trading strategies which show positive evidence of earning abnormal returns with aid of historical data, don't necessary outperform the market when using it in practice. This is because a trading strategy could work in-sample, due to statistically significant which occurred by chance, but is worthless out-of- sample. It could be worthless out-of-sample due to changing market conditions by which a trading strategy is not in line with the current market environment anymore. Before using a trading strategy in practice, it is recommended to test the trading strategy on re-sampled data, with use of actual data points of the sample. This method is also known as bootstrapping.

Fama (1970), Samuelson (1965) and many other academics are skeptical about technical analysis because they believe that markets are efficient and reflect all available information. This view is also known as the Efficient Market Hypothesis, which nowadays is still accepted in financial literature. Using historical data to make abnormal returns is in this view not possible. But given this theory, practitioners still believe that technical analysis has a predictive power. The Efficient Market Hypothesis can be separated in three forms: the weak, semi-strong and strong-form (Fama, 1970). These forms differ by the degree of available information.

- The weak-form: this hypothesis states that abnormal returns cannot be earned by using historical prices, trading volume or open interest;
- The semi-strong-form: this hypothesis states that all public information is, rapidly, reflected in the stock price. Due to this, abnormal returns cannot be earned by trading on this data;
- The strong-form: this hypothesis states that all public and private (insider) information is reflected in the price.

At this moment, the Efficient Market Hypothesis is still accepted within the paradigm. But there has been found evidence which undermines the Efficient Market Hypothesis. This evidence is based on behavioral finance. Milgrom and Stokey (1982) for example concluded that if the markets are efficient, there is no incentive to trade at all. Brown and Jennings (1989) found that behavioral finance contradicts the Efficient Market Hypothesis due to noise traders and Barberis, Shleifer and Vishny (1998) discovered that traders could react in two ways to news; overreaction and underreaction. Thus when this occurs the market is in a

certain time span inefficient since the price deviates from its intrinsic value. Another finding which is not in line with the Efficient Market Hypothesis is the existence of market anomalies. An anomaly is a deviation of the accepted norm or defined value, in this context the Efficient Market Hypothesis. Market anomalies are in relation to calendar events, to technical trading rules and to the structure of the equity. Examples of anomalies are the January-effect, the small-firm effect, the weekend-effect and the momentum effect.

Since it is known that evidence of anomalies in relation to technical trading rules exists, it is interesting whether it is possible for common people to exploit the market with use of straight forward technical trading rules which are publicly attainable on the internet and in the literature regarding to trading securities. The hypothesis which is tested in this thesis is stated below.

H_0 : Candlestick patterns cannot generate abnormal returns
H_1 : Candlestick patterns can generate abnormal returns

The reason of choosing this subject and the purpose of this thesis is to examine whether a non-time-consuming profitable trading strategy, which is based on assumptions, can be developed. This trading strategy is aimed for one who doesn't want the sit behind the screen the entire day watching the price fluctuate and dealing with the emotional aspect, but just want to spend time trading the securities once a day (e.g. at the close of the day). Therefore the daily price levels (i.e. open, high, low and close) are chosen in this trading strategy. The incentive of a trader is to earn money with use of a trading strategy which is profitable in the long term. Key factors of a profitable trading strategy are good entry signals, an exit strategy and a tool which limits the risk. As an entry signal, the *Bullish Engulfing* and *Morning Star* are chosen out of many chart patterns due to the frequent occurrence and showed a high reliability of a trend reversal (Bulkowski, 2008). Furthermore, the chart patterns are commonly known by practitioners and easy to understand. When these patterns are used by many traders, this trading strategy could improve its performance due to the possible herding behaviour. Since these are chart patterns, a candlestick chart is used in this thesis. Furthermore, the chart patterns which are chosen are bullish trend reversal patterns. Therefore a down trend indicator has been used, which is computed with use of three moving averages. This trend indicator is based on the method of Carginalp and Laurent (1998), and it has been chosen due to the fact that Carginalp and Laurent showed that this trend indicator worked in their research. An entry signal is given when the chart pattern occurs which is in a down

trend. The exit strategy, the holding period of 1 to 25 working days, has been chosen since technical analysis is only used in the short term (Park and Irwin, 2004). At last to reduce the exposing risk, a stop-loss is used in the trading strategy. A stop loss is a price level where an open position will be liquidated when reached. The stop loss used in this thesis is the Average True Range, which in general shows positive evidence when using it in a trading strategy (Wilder, 1978). This parameter has a favorable effect on the returns of a trading strategy and is due to the fact that negative extreme values are limited. The period of the dataset examined is from 12/10/1992 till 13/05/2009, which is publicly attainable http://finance.yahoo.com. Question is whether these assumptions, which are known to be a considered to be taken in to account when developing a trading strategy, are profitable when using it together. Therefore different examinations are done with varying parameters (e.g. trend indicator and stop loss) to gain more insight about the effect of the parameters with respect to the performance of the trading strategy.

In the world of technical analysis are many kinds of trading strategies. Popular trading strategies are strategies which take in to account moving average crossovers or channel breakouts. A trading strategy which is solely based on moving averages or channel breakouts has not been chosen on purpose in this thesis, since there has been done already a lot of research on these strategies. Plus in general, these trading strategies detect a trend reversal late relative to a candlestick pattern based strategy. A trading strategy with use of candlestick patterns has been used in this thesis since there hasn't been done much research on this subject. Therefore using candlestick patterns in this thesis has more added value with respect to the financial paradigm.

Based on the result of the examination, which was done in this thesis, one can conclude that trading with use of candlestick patterns is appealing since it is shown that abnormal returns can be earned, although there were no significant signs. The compounded returns of the trading strategies were compared with the compounded interest rate of 3% (165%) and 5% (229%). Most of the strategies outperformed the compounded interest rate. The trading strategy which performed the best had a compounded return of 1577%.

This thesis is divided in seven chapters. First the introduction will be shown in chapter one. In chapter two, technical analysis will be reviewed with use of findings from early studies. Chapter three consist the theories which are still accepted within the paradigm: the efficient market hypothesis and the random walk theory. In chapter four the methodology strategy, will be explained. In chapter five can be read which data has been used in this thesis. The results are shown in chapter six and finally the conclusion can be read in chapter seven.

2 Technical Analysis

Nowadays almost all analysts are familiar with technical analysis. Frankel and Froot (1990) and Taylor and Allen (1992) showed that technical analysis has an important value when deciding whether or not to trade a certain security. Technical analysis is an analysis of securities by using past prices, volumes and open interest (Park and Irwin, 2004). Technical analysis is based on the following assumptions (Murphy, 1999):

- history repeats itself;
- prices move in trends;

Technical analysts believe that patterns or events which occurred in the past will have the same outcome with patterns/events which have the same characteristics in the present. These characteristics can be visually and mathematically explained by graphical visualizations and by indicators like e.g. The Relative Strength Index (Wilder, 1978) and Alexander's Filter Rule (Alexander, 1964). Indicators are calculations based on historical data and are used to give information about price patterns. The main purpose of technical analysis is to detect a trend or trend reversal. Although detecting a trend is subjective and one who undermines technical analysis finds that technical analysis is merely an art. They insinuate that technical analysis is an art, because most technicians draw lines to confirm a trend, trend reversal, support and/or resistance. They also find that technical analysis is a self-fulfilling prophecy due to psychological factors which technicians have to bear with.
Technical analysis is based on human behaviour and is also known as heuristic representativeness (Tversky and Kahneman, 1974). Heuristic representativeness is called when events are judged being similar based on the same characteristics. For example technical analysts tend to believe that past profitable price patterns will also be profitable in the future. Other psychological explanations why technical analysis is popular are: communal reinforcement, selective thinking, conformation bias and self-deception (Sewell, 2008).

- communal reinforcement: a strong belief is formed by a community based on repeatedly claims of those members, rather than on empirical evidence;
- selective thinking: focusing on favorable evidence and ignoring unfavorable evidence;

- conformation bias: this is a type of selective thinking and this forms states that one tends to search for information that is in line with one's beliefs. And on the same time ignores information that is not in line with one's beliefs ;
- self-deception: by ignoring the evidence that contradict one's beliefs, they are misleading themselves by accepting something that could be invalid;

Investors, who rely on technical analysis, have some advantages with respect to fundamental analysis. The main advantage is that technical analysis is cheaper and can be applied more easily on securities than fundamental analysis. Since technical analysis only uses historical information, which nowadays is easily attainable on public databanks. Also fundamental analysis is in general more complex, with use of firm specific factors, although one can make technical analysis as complex as it can be.

Many academics have done research on technical analysis the last century. During this period, significant and insignificant results have been identified. For example, in some studies there was evidence that technical analysis was profitable on the foreign exchange and the futures market (Park and Irwin, 2004). Brock et al. (1992) found evidence that technical trading rules could outperform the market with use of 90 years of data. Blume et al. (1994) showed that traders who take into account information about the volumes do better than traders who don't use this information. Lee and Swaminathan (2000) also found evidence of the importance of using information about the volume when trading securities. Volumes are important because they could reflect the buy and sell pressure. Traders usually use this information to decide to open a position when the stock price is near support and resistance, when a moving average crossover has occurred, when a momentum oscillator is in the traders favor or when a chart pattern is formed (for explanation see below).

- support and resistance level: this psychological level shows a possible trend reversal. When these levels are broken, they could show a trend continuation;
- moving average crossover: a moving average, in technical analysis, resembles the average price of a security over a certain period. When a shorter moving average crosses the longer moving average, a buy/sell signal is given;

- momentum oscillator: this is an indicator which shows when to buy, sell and to be neutral. Usually momentum oscillators are used to discover oversold and overbought conditions of the trend in the short term;
- chart pattern: this is a combination of various price formations. Chart patterns can be used on both a short and a long time span;

There are studies which also showed positive evidence of using technical analysis with respect solely to support and resistance (Brock et al, 1992), moving average crossovers (Griffioen, 2003), momentum trading (Lo et al, 2000) and chart trading (Carginalp and Laurent, 1998).

A negative aspect of technical analysis is that trading systems and parameters could be over-optimalized with respect to the data-set. This phenomenon is also known as data-snooping. Data-snooping is misusing the parameters/data so that the result could reflect an unrealistic view and usually reflect a positive bias in favor of the researcher (White, 2000). Trading systems which show positive evidence of earning abnormal returns with aid of historical data, don't necessary outperform the market when using it in practice. This is because a trading strategy could work in-sample, due to statistically significant which occurred by chance, but is worthless out-of- sample. It could be worthless out-of-sample due to changing market conditions by which a trading strategy is not in line with the current market environment anymore.

3 Efficient Market Hypothesis and Random Walk Theory

Due to the Efficient Market Hypothesis and Random Walk Theory, academics are skeptical about technical analysis. Bachelier (1900), the pioneer on the Random Walk Theory, concluded in his thesis "Theorie de la Speculation" that the stock prices move randomly and it is not possible to predict price movements by using past information. Also Griffioen (2003) stated that stock prices are well defined by random walks.

When the Efficient Market Hypothesis is true, prices reflect all information (Fama, 1970). Using historical data to make abnormal returns is in this view not possible. But given these theories, practitioners still believe that technical analysis has a predictive power. Samuelson (1965) wrote an article which described that prices are optimal priced when they include all

information. Samuelson stated that fluctuating prices are due to the efficient market. The Efficient Market Hypothesis was created based on this observation and can be separated in three forms: the weak, semi-strong and strong-form (Fama, 1970). These forms differ by the degree of available information.

- The weak-form: this hypothesis states that abnormal returns cannot be earned by using historical prices, trading volume or open interest. This form implies that technical analysis does not have a predictive power;
- The semi-strong-form: this hypothesis states that all public information is, rapidly, reflected in the stock price. Due to this, abnormal returns cannot be earned by trading on this data;
- The strong-form: this hypothesis states that all public and private (insider) information is reflected in the price.

At this moment, the Efficient Market Hypothesis is still accepted in the financial world. But the Efficient Market Hypothesis had resistance the past decades by academics who have tried to undermine this theory. Milgrom and Stokey (1982) for example, concluded that if the markets are efficient, there is no incentive to trade at all. Brown and Jennings (1989) found that behavioral finance contradicts the Efficient Market Hypothesis due to noise traders. Noise traders are traders who take into account noise as information. De Long et al. (1991) found evidence that noise traders outperform the market on the long run. This is explained because they bear more risk relative to traders who act rationally.

Due to supply and demand, all traders together are the “market”. Knowing that the behavior of traders could be influenced by psychological reasons (e.g. herding behavior), the market could be inefficient. Even with existence of arbitrageurs due to noise risk. Noise risk is risk created by noise traders when the price deviates from the intrinsic value. Question for arbitrageurs is whether to ride along with noise traders or to counter trade them.

Barberis, Shleifer and Vishny (1998) discovered that traders could react in two ways to news; overreaction and underreaction. Overreaction takes place in the long term. Investors tend to overestimate stock prices due to a gulf of good news. Due to time on time upward driven stock prices and good news, the expected return after another good news will be higher than it would be if there was no gulf of good news. Underreaction takes place in the short term and that is because news is not fully reflected in the price immediately. The part which remains will be reflected in the price days after the news came out (Barberis et al, 1998).

4 Methodology

The trading rules within technical analysis can be divided in objective and subjective trading rules. The objective trading rules consist a mathematically approach of historical prices. The subjective trading rule approaches the historical prices by drawing support and resistances. Since the subjective aspect of technical analysis cannot be computed on the computer, objective trading rules will be used in this thesis.

The main purpose of a trading system is to have a positive return on the long run. Since early studies revealed that technical analysis cannot predict the future entirely, negative returns are unavoidable (Park and Irwin, 2004). To reduce the risk a stop-loss is used in the trading strategy. The entry signal consists of a chart pattern in combination with a downtrend, which will be explained further in this chapter. The exit strategy is the holding period which varies from 1 to 25 working days.

4.1 Pattern definitions

Patterns consist of either black or white candles. A black candle has a close lower than the open, while the white candle has a close higher than the open. The high and the low of a candle represent the trading range of that candle (Figure 4.1).

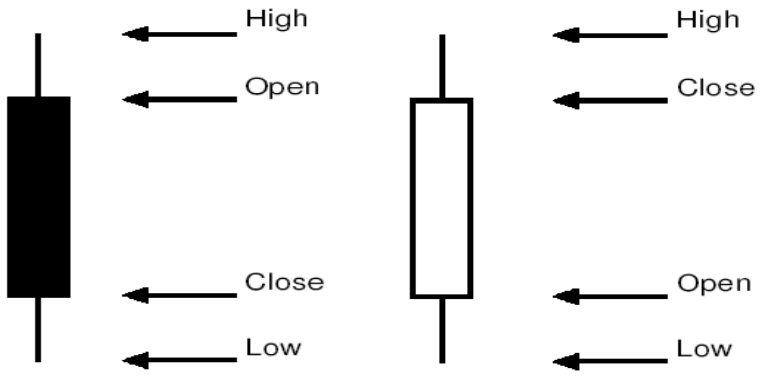

Figure 4.1 Overview candles

The candles in this thesis represent one trading day. Candlestick patterns consist of two or more candles. The first, second and n^{th} day of a pattern are respectively labeled as t*+1, t*+2 and t*+n.

4.1.1 Bullish Engulfing

The Bullish Engulfing pattern is composed of a black and a white candlestick, respectively on the first and second day of this pattern (Bulkowski, 2008). With due observance of the white candle on day two engulfs the black candle (Figure 4.2). As implied by its name, this pattern suggests that the Bulls have taken control after a downtrend. In order to compute this mathematically the definition is described below.

Definition (Bullish Engulfing)

1. The first day of the pattern belongs to a downtrend (see chapter 4.2) and has a higher open than close:

   $o_{t^*+1} > c_{t^*+1}$

2. The second day must completely engulf the first day in the sense of the following:

   $c_{t^*+2} > o_{t^*+1} > c_{t^*+1} > o_{t^*+2}$

where o_{t^*+1} and c_{t^*+1} are the open and close of the first day of the pattern. Further o_{t^*+2} and c_{t^*+2} are the open and close of the second day of the pattern.

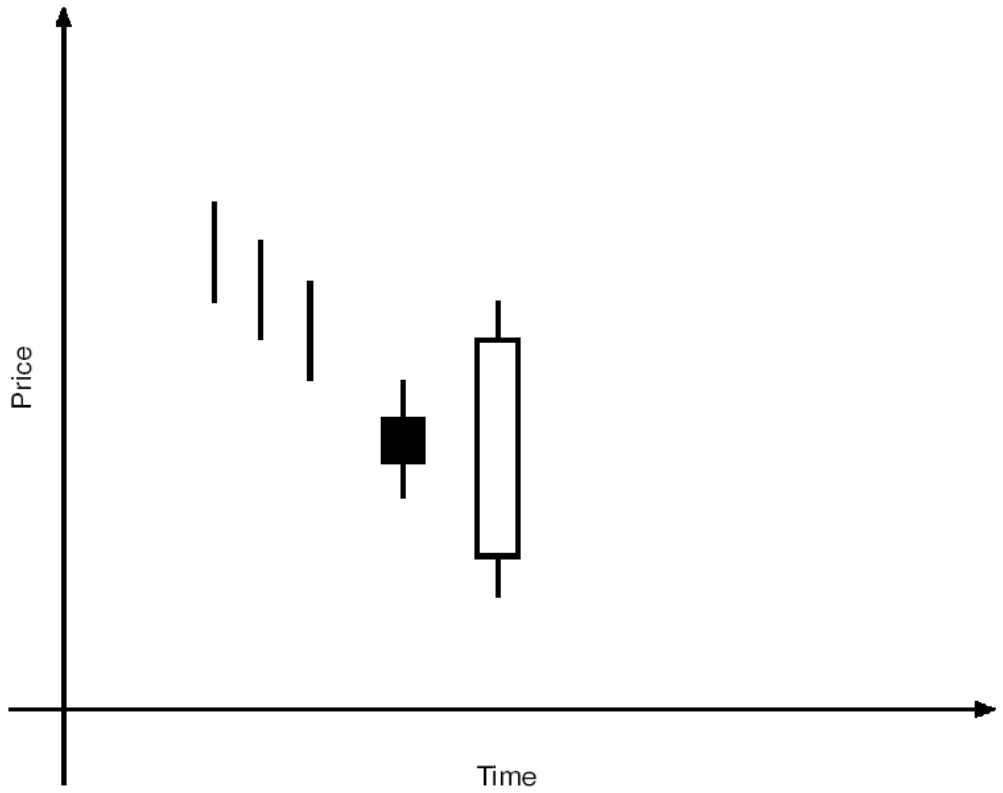

Figure 4.2 Bullish Engulfing

4.1.2 Morning Star

The Morning Star is a three-day pattern where the first day must be black. The second day must be gapped down and can either be black or white. The third day must be white and gapped up prior to day two (Figure 4.3). In order to compute this mathematically, the definition is described below.

Definition (Morning Star)

1. The first day of the pattern belongs to a downtrend (see chapter 4.2) and has a higher open than close:

   $o_{t^*+1} > c_{t^*+1}$

2. The second day must be gapped down from the first day, and can be black or white:

   $c_{t^*+1} > c_{t^*+2}$ and $c_{t^*+1} > o_{t^*+2}$

3. The third day, which is a white day, must be gapped up from the second day:

   $c_{t^*+3} > o_{t^*+3}$

   $o_{t^*+3} > c_{t^*+2}$ and $o_{t^*+3} > o_{t^*+2}$

where o_{t^*+1}, c_{t^*+1}, o_{t^*+2}, c_{t^*+2}, o_{t^*+3} and c_{t^*+3} are the open and close of respectively the first, second and third day of the pattern.

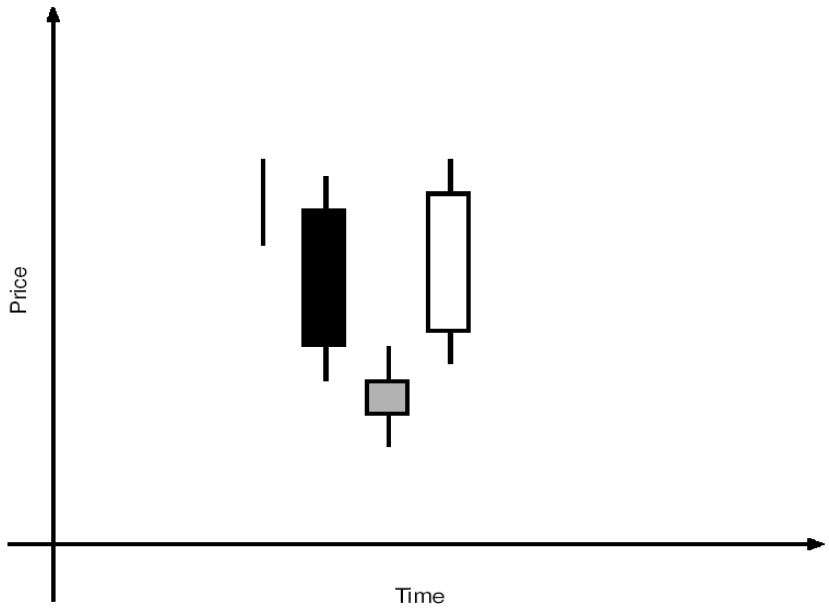

Figure 4.3 Morning Star

4.2 Trend definition

The objective of this study is to determine whether the Bullish Engulfing and Morning Star have predictive value as reversal patterns. Due to the fact that the Bullish Engulfing and Morning Star are bullish and reversal patterns, a downtrend has to be defined.

Carginalp and Laurent (1998) defined a downtrend by using moving averages of the daily closing prices. A downtrend occurred when the 6-day average was greater than the 5-day average. Plus the 5-day average has to be greater than the 4-day average. The n-day moving average at time t* is defined by:

- $M_{avg}{}^{(n)}_{t} = 1/n\ (c_t + c_{t-1} + ... + c_{t-n})$

where $M_{avg}{}^{(n)}_{t}$ is the moving average at time *t* of the last *n* observed closing prices. And *c* is the closing price at time *t*. The downtrend defined by Carginalp and Laurent is as follows:

- $M_{avg}{}^{6}_{t} > M_{avg}{}^{5}_{t} > M_{avg}{}^{4}_{t}$

The main idea of using the moving averages, which are described above, is that they are double the timeframe of the timeframe of the patterns (Carginalp and Laurent, 1998). Further these moving averages are used to smooth out short-term fluctuations.

4.3 Stop Loss definition and exit strategy

The main idea of a stop loss within a trading strategy is to limit the losses, and let the profit run. To take into account the volatility of the AEX-index, the Average True Range (ATR) is used. The ATR is an indicator developed by J. Wilder (1978), based on the idea that prices move in a range. According to Wilder (1978) the ATR is a 14-day average of the True Range (TR), where the TR is the largest of the following:

- The difference between $high_t$ and low_t;
- The difference between $high_t$ and $close_{t-1}$;
- The difference between low_t and $close_{t-1}$;

The stop loss is set to two times the ATR under the price level on time *t*, when a long position is taken. The reason of setting the stop loss to two times the ATR is to have enough room for the price to fluctuate and limit tolerable possible losses. In order to compute this mathematically, the definition is described below:

- True Range$_t$ = max(h_t - l_t, h_t - c_{t-1}, l_t - c_{t-1});
- Average True Range$_t$ = 1/14 (TR_t + TR_{t-1}+ ... + TR_{t-14});
- Stop loss$_t$ = c_t – 2*ATR_t;

where h_t is the high on time *t*, l_t is the low on time *t*, TR_t is the True range on time *t*, ATR_t is the average of the 14 last observed True Ranges.

Since technical analysis is a tool to predict price movements at shorter time horizons (Park and Irwin, 2004), an exit strategy is chosen based on the holding period. The exit strategy is the holding period which varies from 1 to 25 working days (one to five weeks). If all conditions are satisfied (pattern and downtrend), a long position is taken on the close of the last day of the pattern. After n-days the position will be liquidated and the return will be analyzed. The holding period return of n-days (HPR_n) is mathematically computed as follows:

- $HPR_n = (c_{t+n} - c_t)/ c_t$;

where c_{t+n} is the closing price on time *t+n* and c_t is the closing price on time *t*. When the price between *t* and *t+n* is lower than the stop-loss level of time *t*, the HPR_n will be:

- $HPR_n = ((c_t – 2*ATR_t) - c_t)/ c_t$;

The formula described above is computed due to the fact that when the price on time *t+n* is less than the stop-loss level on time *t*, the strategy will be liquidated. Every holding period strategy which exceeds the time when the position was taken and when the price was less than the stop-loss will be liquidated. For example, if the price is less than the stop-loss of time *t* on time *t+6*, holding period strategies equal and greater than *t+6* will be liquidated on time *t+6*.

4.4 Hypothesis testing

The returns of each holding period strategy will be analyzed based on the average return, standard deviation, skewness, kurtosis and Bera-Jarque. The average return gives an overall view of the performance of the strategies. The standard deviation is a measurement of the variability of the dataset. When a dataset has a low variability, the standard deviation is small and the data points are close to the average return (mean). When the standard deviation is high, the opposite is measured (Brooks, 2006).

Skewness is a measurement of the symmetry of the dataset about its mean value. Skewness can be divided in three groups: no skewness, positive skewed and negative skewed. A dataset is symmetric, like the normal distribution, when it has zero skewness. A dataset is called positively skewed when it has a long right tail. The opposite is measured for a negative skewed dataset (Brooks, 2006). The skewness test is used since, in practice, not every distribution is normal distributed. Knowing the symmetric can be useful to understand where the extreme values are measured.

Kurtosis is a measurement of the peakedness/flatness of the distribution. The normal distribution has a kurtosis of 3 (mesokurtic). When the kurtosis is higher than 3 (leptokurtic), the distribution is peaked and the extreme values have a relative high effect on the variance. When the kurtosis is less than 3 (platykurtic), the opposite is measured (Brooks, 2006).

The Bera-Jarque is a test for normality, based on skewness and kurtosis. When this test measures a high value and a low corresponding p-value, the distribution is said not to be normal distributed.

In order to test these technical trading rules a hypothesis has to be formulated. In this thesis will be tested if simple technical trading rules can generate abnormal returns on the long term. When formulated in hypothetical context, the hypothesis will be:

- **H_0 : Candlestick patterns cannot generate abnormal returns**

In this thesis, an abnormal return on the long-term is described as the compounded holding period return which exceeds the compounded interest rate of 17 years. The number of years is discussed in chapter 5.

5 Data

This thesis will examine whether it is possible to predict AEX-index. The AEX-index was published in 1983 and is composed out of 25 most traded stocks in The Netherlands over the last calendar year. The AEX-index is based on a weighted average, corresponding to the market capitalization of the whole index with respect to the stock (Euronext.com). The weight of each stock is not allowed to exceed 15% of the whole index. Since the AEX-index is a weighted average of 25 constituents, it is less sensitive for extreme fluctuations relative to many individual stocks.

The data used in this thesis are based on the daily high, low, open en close levels of the AEX-index. The period of the dataset examined is from 12/10/1992 till 13/05/2009 (for simplicity 17 years). The reason of selecting this period is because these data were publicly attainable on http://finance.yahoo.com. This period also covers both the Bull and Bear market, which will give a more reliable performance of the strategy. Thus the results cover the overall performances of the strategies in both good and bad times.

6 Empirical results

To test if the results are abnormal, a sensitive analysis of the interest rate has been done. For simplicity an interest rate of 3% and 5% has been used and the compounded returns are respectively 165% and 229%. As stated before, in this thesis an abnormal return on the long-term is described as the compounded holding period return which exceeds the compounded interest rate. The returns of the trading strategy which is discussed in this thesis are computed in Excel and analyzed in Eviews. As shown in table 6.1, 98 buy-signals are generated in 17 years and the holding period return strategies as from 10 days show a sign of an abnormal return. All the holding period return strategies are leptokurtic (kurtosis higher than 3), thus the distribution is peaked and the extreme values have a relative high effect on the variance. Also can be seen that HPR2 till HPR10 are negatively skewed and these distributions have a long left tail. The opposite is measured for the remaining holding period strategies. Also as from HPR10, except HRP12, there are signs of normality. Signs of normality are present due to probability values which are higher than 0.05. Further HPRS-3 is the only strategy which has a mean below zero. Although there are strategies with abnormal returns (in the sense of this

thesis), the mean of each HPR does not differ significant from zero, based on the normal distribution with a mean of 0% and a standard deviation of 1%.

Table 6.1 Results of the trading strategy

Results generated with a trend indicator and a stop loss of 2 times the ATR. The underlined compounded returns are between or greater than the compounded interest rate.

	Interest	HPR1	HPR2	HPR3	HPR4	HPR5
Mean	0.05-0.03	0.001619	0.001473	1.50E-05	0.003609	0.004017
Std. Dev.	0.00	0.016530	0.022780	0.030543	0.031210	0.032636
Skewness	N/A	0.382346	-0.218476	-0.234110	-0.580169	-0.384958
Kurtosis	N/A	6.477.544	5.099.773	9.082.781	7.250.429	8.111.478
Jarque-Bera	N/A	5.176.877	1.878.322	1.519.794	7.926.784	1.091.066
Probability	N/A	0.000000	0.000083	0.000000	0.000000	0.000000
Observations	17	98	98	98	98	98
Compounded return	2,29 - 1,65	1,16	1,13	0,96	1,36	1,41

	HPR6	HPR7	HPR8	HPR9	HPR10	HPR11
Mean	0.004191	0.003752	0.005192	0.005824	0.006376	0.007560
Std. Dev.	0.036343	0.039451	0.040980	0.041201	0.042014	0.042639
Skewness	-0.442366	-0.206830	-0.043818	-0.082027	-0.033328	0.018597
Kurtosis	6.725.977	5.013.509	4.693.017	4.466.694	4.156.627	4.123.988
Jarque-Bera	5.988.476	1.725.345	1.173.545	8.893.928	5.480.773	5.164.323
Probability	0.000000	0.000179	0.002829	0.011714	0.064545	0.075610
Observations	98	98	98	98	98	98
Compounded return	1,41	1,34	1,53	1,63	1,71	1,92

	HPR12	HPR13	HPR14	HPR15	HPR20	HPR25
Mean	0.008464	0.007753	0.007752	0.008495	0.009057	0.010089
Std. Dev.	0.046810	0.046472	0.049307	0.050390	0.053445	0.055987
Skewness	0.484339	0.258708	0.344972	0.461851	0.514023	0.309751
Kurtosis	4.689.018	4.171.064	3.458.018	3.833.213	3.794.395	2.988.827
Jarque-Bera	1.548.041	6.693.035	2.800.362	6.318.834	6.892.431	1.567.627
Probability	0.000435	0.035207	0.246552	0.042450	0.031866	0.456661
Observations	98	98	98	98	98	98
Compounded return	2,06	1,92	1,90	2,03	2,12	2,31

Since the trading strategy has parameters which were based on assumptions (e.g. trend definition and stop loss), more analysis has been done to give more insight about the characteristics of the parameters by varying the parameters. An analysis has been done without a trend indicator and without a stop loss, thus solely based on the chart pattern. There also has been done an analysis without a trend indicator and with a stop loss of an ATR of 1.5 and 2. For extensive results of the strategies with varying parameters see table A1, table A2 and table A3 of the appendix.

As shown in table 6.2 one can conclude that with use of the trend indicator, lower compounded returns can be earned with respect to the other strategies. This is also due to the fact that strategies without a trend indicator generated more buy signals (239). In general the strategy without a trend indicator and with a stop loss of an ATR of 2 has the best performance, especially with a longer holding period. Although in some cases the strategy without a trend indicator and without a stop loss has the best performance. The means, on the other hand, showed mixed results (see table 6.3). The means of the trading strategy with use of a trend indicator on the short-term out-performances the other strategies. With regarding to this result, the trend indicator has a positive effect on the reward/risk ratio per trade. Further one can conclude that, except for one, all strategies have a positive mean.

Table 6.2 Compounded returns

This table shows the compounded returns of the trading. The underlined compounded returns are between or greater than the compounded return of 3 % (165%) and 5% (229%). The compounded returns of the trading strategy which takes in to account a trend indicator is inferior with respect to the other trading strategies.

HPR	Trend/ 2*ATR	No trend/ 2*ATR	No trend/ 1.5*ATR	No trend/ No Stoploss
1	116%	146%	147%	141%
2	113%	145%	148%	138%
3	96%	118%	123%	110%
4	136%	188%	168%	159%
5	141%	202%	174%	189%
6	141%	203%	171%	187%
7	134%	211%	188%	209%
8	153%	286%	248%	346%
9	163%	358%	309%	348%
10	171%	387%	306%	413%
11	192%	398%	313%	401%
12	206%	410%	339%	488%
13	192%	414%	332%	514%
14	190%	491%	413%	447%
15	203%	600%	499%	630%
20	212%	835%	620%	783%
25	231%	1577%	1143%	1195%

Table 6.3 means

This table shows the arithmetic means of the trading strategies. The underlined mean is the only negative mean. In contrast with the compounded return, the mean of the strategy which takes in to account a trend indicator is not inferior with respect to the other trading strategies

HPR	Trend/ 2*ATR	No trend/ 2*ATR	No trend/ 1.5*ATR	No trend/ No Stoploss
1	0,162%	0,167%	0,167%	0,155%
2	0,147%	0,171%	0,171%	0,155%
3	-0,002%	0,099%	0,111%	0,071%
4	0,361%	0,297%	0,249%	0,234%
5	0,402%	0,332%	0,276%	0,317%
6	0,419%	0,342%	0,281%	0,321%
7	0,375%	0,365%	0,327%	0,377%
8	0,519%	0,498%	0,446%	0,590%
9	0,582%	0,598%	0,546%	0,614%
10	0,638%	0,635%	0,544%	0,690%
11	0,756%	0,649%	0,555%	0,698%
12	0,846%	0,670%	0,597%	0,782%
13	0,775%	0,677%	0,589%	0,820%
14	0,775%	0,759%	0,689%	0,779%
15	0,850%	0,849%	0,772%	0,945%
20	0,906%	1,003%	0,874%	1,072%
25	1,009%	1,294%	1,150%	1,311%

Further no sign of normality is found in the trading strategies without use of a trend indicator. Overall, with the exception of a few, all strategies with use of a stop loss have a positive skewness, thus with a long right tail (positive extreme values). The trading strategy which uses no stop loss is the only strategy with negative skewness for all HPR (see table A3).

7 Conclusion

Technical analysis was researched by many academics the last decades. Academics found both significant and insignificant proof of the predictive power of technical analysis. Although there is still no consensus about technical analysis and skepticism still exists amongst academics, many traders take into account technical analysis when trading. Due to the popularity of technical analysis, a study has been done in this thesis, based on assumptions which are generally known and widespread amongst technical analysts.

In order to test if technical analysis is significant, thus contradicts the efficient market hypothesis, a trading strategy was created. This trading strategy was based on two candlestick patterns, a trend indicator, a stop loss and an exit strategy. Since the parameters are based on assumptions, more analysis has been done by varying the parameters. The parameters which varied were the trend indicator and stop loss.

Based on the results one can conclude that technical analysis can be profitable, but the results were not significant. The efficient market hypothesis thus still stands. The profitable aspect of this trading strategy could be explained by the findings of Sewell. Sewell (2008) stated that the stock market, e.g. AEX-index, has an upward drift. But this finding, positive autocorrelation, is not tested in this thesis. Before using a trading strategy in practice, it is recommended to test the trading strategy on re-sampled data, with use of actual data points of the sample. This method is also known as bootstrapping. Also is recommended to examine holding periods which were not taken into account in this thesis (e.g. 21, 22, 23, 24 and greater than 25 days). One who wishes to trade this strategy has to be cautious, because transaction costs, bid/ask spreads, taxes and slippage were not taken into account. Also one who trades an $HPRS_n$ with all of his equity in practice, the next *n* days no other position can be taken when a new signal occurs, thus the compounded return will be lower in reality and less signals can be considered as tradable. This is because there is no equity left to open a new position.

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Appendix

Table A1. Results of trading system without trend indicator and with 2 times ATR-stoploss

Results generated, with varying holding periods, without a trend indicator and with a stop loss of 2 times the ATR. The underlined compounded returns are between or greater than the compounded interest rate.

	Interest	NUM1	NUM2	NUM3	NUM4	NUM5
Mean	**0.05-0.03**	0.001671	0.001708	0.000985	0.002969	0.003320
Median	**0.05-0.03**	0.000975	0.002453	0.002308	0.004326	0.005383
Std. Dev.	**0.00**	0.012760	0.018194	0.024618	0.025712	0.027620
Skewness	**N/A**	0.340581	-0.447575	-0.388228	-0.465627	-0.260716
Kurtosis	**N/A**	8.490.208	6.754.061	9.895.699	7.388.199	7.414.446
Jarque-Bera	**N/A**	3.047.884	1.483.221	4.795.291	2.003.968	1.967.690
Probability	**N/A**	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	**17**	239	239	239	239	239
Compunded return	**229% - 165%**	146,20%	144,54%	117,66%	187,68%	201,64%

	NUM6	NUM7	NUM8	NUM9	NUM10	NUM11
Mean	0.003417	0.003654	0.004975	0.005980	0.006345	0.006486
Median	0.006804	0.005932	0.006828	0.006115	0.007668	0.009155
Std. Dev.	0.030227	0.032256	0.033955	0.035614	0.036570	0.037223
Skewness	-0.213831	-0.123843	0.056117	0.133507	0.124285	0.132844
Kurtosis	6.767.373	5.353.133	4.937.628	4.356.242	3.945.556	3.848.504
Jarque-Bera	1.431.610	5.575.256	3.751.303	1.902.728	9.518.812	7.872.561
Probability	0.000000	0.000000	0.000000	0.000074	0.008571	0.019521
Observations	239	239	239	239	239	239
Compunded return	202,69%	211,30%	285,78%	358,16%	387,68%	398,49%

	NUM12	NUM13	NUM14	NUM15	NUM20	NUM25
Mean	0.006697	0.006769	0.007588	0.008488	0.010027	0.012942
Median	0.003384	0.001955	0.003647	0.001498	9.22E-05	-0.000755
Std. Dev.	0.039869	0.040431	0.042973	0.044382	0.047764	0.052423
Skewness	0.477948	0.316332	0.351816	0.445893	0.506392	0.441517
Kurtosis	4.513.401	3.978.562	3.302.917	3.554.531	3.430.238	2.811.758
Jarque-Bera	3.190.769	1.352.189	5.844.125	1.098.191	1.205.790	8.117.872
Probability	0.000000	0.001158	0.053823	0.004124	0.002408	0.017267
Observations	239	239	239	239	239	239
Compunded return	409,73%	414,27%	491,23%	600,10%	834,55%	1577,11%

Table A2. Results of trading system without trend indicator and with 1.5 times ATR-stoploss

Results generated, with varying holding periods, without a trend indicator and with a stop loss of 1.5 times the ATR. The underlined compounded returns are returns which are between or greater than the compounded interest rate.

	Interest	NUM1	NUM2	NUM3	NUM4	NUM5
Mean	**0.05-0.03**	0.001674	0.001709	0.001112	0.002486	0.002755
Median	**0.05-0.03**	0.000975	0.002453	0.001893	0.002929	0.003280
Std. Dev.	**0.00**	0.012752	0.018012	0.023286	0.024819	0.026239
Skewness	**N/A**	0.376456	-0.370133	0.243339	0.043454	0.270582
Kurtosis	**N/A**	8.111.455	6.667.287	8.161.227	5.357.159	6.293.547
Jarque-Bera	**N/A**	2.658.262	1.393.867	2.676.314	5.540.570	1.109.389
Probability	**N/A**	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	**17**	239	239	239	239	239
Compunded return	**229% - 165%**	147,10%	148,12%	122,87%	168,31%	174,38%

	NUM6	NUM7	NUM8	NUM9	NUM10	NUM11
Mean	0.002814	0.003266	0.004463	0.005456	0.005435	0.005551
Median	0.003320	0.001535	0.003766	0.002710	0.000446	-0.001243
Std. Dev.	0.028504	0.030261	0.031718	0.033650	0.034325	0.034842
Skewness	0.226001	0.265256	0.491210	0.545736	0.459155	0.489719
Kurtosis	6.363.372	5.053.811	4.630.243	4.056.876	3.496.601	3.538.229
Jarque-Bera	1.146.859	4.480.834	3.607.744	2.298.679	1.085.366	1.243.786
Probability	0.000000	0.000000	0.000000	0.000010	0.004397	0.001991
Observations	239	239	239	239	239	239
Compunded return	171,01%	188,22%	247,82%	309,40%	306,12%	313,45%

	NUM12	NUM13	NUM14	NUM15	NUM20	NUM25
Mean	0.005966	0.005891	0.006889	0.007722	0.008740	0.011498
Median	-0.003841	-0.005875	-0.010329	-0.009485	-0.011040	-0.011573
Std. Dev.	0.037283	0.037714	0.039923	0.040829	0.043418	0.047427
Skewness	0.853142	0.702851	0.709486	0.749255	0.742135	0.651101
Kurtosis	4.758.913	4.165.412	3.485.093	3.759.750	3.380.174	2.748.373
Jarque-Bera	5.980.160	3.320.292	2.239.426	2.810.991	2.337.811	1.751.718
Probability	0.000000	0.000000	0.000014	0.000001	0.000008	0.000157
Observations	239	239	239	239	239	239
Compunded return	339,44%	331,98%	412,75%	499,05%	619,87%	1143,18%

Table A3. Results of trading system without a trend indicator and without a stop loss

Results generated, with varying holding periods, solely based on the candlestick patterns. The underlined compounded returns are returns which are between or greater than the compounded interest rate.

	Interest	NUM1	NUM2	NUM3	NUM4	NUM5
Mean	**0.05-0.03**	0.001552	0.001553	0.000713	0.002336	0.003167
Median	**0.05-0.04**	0.000965	0.002308	0.002183	0.004296	0.006747
Std. Dev.	**0.00**	0.013141	0.019125	0.025304	0.027170	0.030066
Skewness	**N/A**	-0.010466	-1.268.033	-0.581574	-0.870998	-1.150.935
Kurtosis	**N/A**	1.000.974	1.232.574	9.958.466	7.708.998	9.910.858
Jarque-Bera	**N/A**	4.831.800	9.184.433	4.894.362	2.478.906	5.217.425
Probability	**N/A**	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	**17**	239	239	239	239	239
Compunded return	**229% - 165%**	141,29%	138,07%	109,63%	158,82%	189,24%

	NUM6	NUM7	NUM8	NUM9	NUM10	NUM11
Mean	0.003209	0.003771	0.005900	0.006135	0.006901	0.006981
Median	0.007675	0.007683	0.007912	0.009461	0.009946	0.011187
Std. Dev.	0.032819	0.035496	0.035339	0.040300	0.041189	0.045159
Skewness	-1.013.770	-1.074.392	-0.688968	-1.222.742	-1.242.138	-1.864.003
Kurtosis	8.286.371	7.378.158	6.743.350	8.867.285	9.172.356	1.334.234
Jarque-Bera	3.152.235	2.338.912	1.564.619	3.973.200	4.353.177	1.188.476
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	239	239	239	239	239	239
Compunded return	187,21%	208,97%	345,69%	348,11%	412,93%	400,84%

	NUM12	NUM13	NUM14	NUM15	NUM20	NUM25
Mean	0.007822	0.008199	0.007786	0.009453	0.010720	0.013107
Median	0.010786	0.011332	0.012478	0.012510	0.014461	0.020089
Std. Dev.	0.046012	0.048609	0.052094	0.054942	0.060598	0.068922
Skewness	-0.921209	-1.450.809	-1.402.292	-1.834.761	-1.541.594	-1.438.295
Kurtosis	7.871.296	9.507.658	9.705.981	1.368.401	1.017.632	7.938.056
Jarque-Bera	2.667.197	4.992.285	5.195.528	1.254.866	5.998.893	3.211.485
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	239	239	239	239	239	239
Compunded return	487,78%	514,36%	446,53%	629,67%	783,11%	1195,36%