UNIVERSITY OF GOTHENBURG
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Technical Analysis

- *A comparative study between a Moving average and a buy-and-hold strategy*

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Abstract

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Title: Technical Analysis, A comparative study between a Moving average and a buy-and-hold strategy.

Background and research question:
There are shared opinions about whether it is possible to forecast the direction of prices through studying previous of market data. According to the efficient market hypothesis, using technical analysis is not an efficient method to predict asset prices, implying that stock market prices are unpredictable. In the light of this and also because there is relatively little research on technical analysis, we find this research question relevant for stock market participants and other that find this interesting. Is it possible to accomplish positive return on the Swedish stock market by using the technical analysis and moving average method in particular as a trading strategy?

Purpose:
The purpose of this study is to determine the efficiency of using the moving average as a trading strategy when forecasting the direction of asset prices of companies listed on Nasdaq Stockholm to exceed the buy-and-hold strategy.

Conclusion:
The price development on OMXS30 suffer from serial correlation and are therefore not possible to predict with help of technical analysis.

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1.Introduction

Within this year, the financial markets have fluctuated tremendously; essentially shifting with no clear direction. For better clarification, the market prices increased slightly during the beginning of this year in January, then decreased heavily a month later in February. This shift is majorly due to the President of the United States Donald Trump's announcement regarding an upcoming trading war. (Mitelman, 2018, 10 May) This announcement was one amongst many that caused the decline of market prices. A trade war seems to be as a matter of fact and many actors in the market were interested in forecasting stock market prices and many even went further to speculated a stock market crash. (Hillerbrand Rune, 2018, 23 Mars) Is it possible to forecast stock market prices? Many believe it is impossible to predict asset trends based on available information in the market, however, there are some researcher who believe that it is possible to use various investment analysis techniques to predict asset trends and thus benefit from undervalued assets.

The efficient market hypothesis states that financial assets are always correctly priced due to all the information available in the market and a change in price only occurs if new information is generated. (Fama,1970) If this theory is true, why do market actors frequently use the technical analysis method in the financial market? In the light of this, the purpose of this study is to examine the technical analysis method and particularly the moving average as a trading strategy and whether using this method could give investors an edge over other investors using buy-and-hold.[1]

1.2 Background

The interest of trading securities has increased a lot in Sweden and have been a huge part of the swedes' life. The word "security" is a collective name which includes stocks, funds, and derivatives. These few are options among all the securities that one could save in. Stocks are one of the most common saving strategy among swedes, and the main reason is that stocks have historically generated the best return throughout the years. (Oxenstierna, 2011) However, choosing what stocks to invest in depends on many factors, factors that an investor base their decisions on. What are these decisions based on? Could a trading strategy method such as the moving average help an investor to maximize their returns?

The two most common techniques while analyzing stocks are the Fundamental analysis and the Technical analysis. The fundamental analysis is the counterpart to the technical analysis, which aims to predict an actual price of a stock based on a company's ratios. The actual price that is generated indicates whether a stock is over- or undervalued and based on that information an investor can decide what to do, either buying or selling. Fundamental analysis barely describes the fluctuations of the market, which is the main reason why technical analysis is primarily used. Technical analysis aims to estimate future market prices based on a company's past prices and thus estimating earnings. (Holmlund & Holmlund, 1984) In other words, the approach is used to identify price trends quite early, essentially identifying the rises and falls of the market trends. (Brock et al, 1992) Technical analysis is a general name that has a variety of different analyzing techniques and methods that can be used to study previous market data and essentially predicts future market fluctuations.

[1] A passive investment strategy for which an investor buys securities and holds them for a sufficient amount of time, regardless of the fluctuations in the market.

Charles Dow, the founder of the Dow Jones Industrial index, theorized during the 19 th century that history repeat itself and that people in group act in a certain way. Essentially, this is what technical analysis is about, the general idea that the movements in the past could be used to predict future prices. (Bernhardsson, 2002,)

Technical analysis includes many forecasting methods, for example chart analysis, computerized analysis, and cycle analysis. (Gehrig & Menkhoff, 2006) The reason why many don't prefer technical analysis is because the lack of scientific evidence in this field. Some argue that technical analysis doesn't work as an analyzing method, while others consider it a good method for predicting future stock prices. (Gehrig & Menkhoff, 2006) Some studies have shown that using technical analysis as an investing strategy will generate significant earnings only if excluding trading fees. However, many well-known institutions still rely heavily on this this method to predict future market prices. For example, the Swedish newspaper Dagens Industri often uses this method as an investing strategy (Di, teknisk analys). In fact, technical analysis is the most common method used by currency traders and the second most common method used by fund managers. (Gehrig & Menkhoff, 2006) These are just a handful of many examples in which different perspectives use technical analysis as a tool for predicting future stock prices.

Essentially, the efficient market hypothesis states that price fluctuations are random and has nothing to do with past prices. Stock market prices in an effective market will adjust to current information immediately. (Fama, 1970) Prices of securities at any time will reflect all the available information in the market, both current and expected information. Thus, the current price of a security is a good prediction of its intrinsic value. (Fama, 1970)

1.3 Problem Discussion

As mentioned earlier fundamental analysis is a frequently used method which uses a company's financial ratio to estimate a specific actual market price of a stock. (Bernhardsson, 2002)
Could technical analysis generate profits? Many actors in the financial market have asked this question for decades. The fact that fundamental analysis is mostly applicable in short term implies that the market prices could be over or undervalued in a shorter perspective. By using technical analysis as a trading strategy, investors can strike the market and get higher returns than the average return. (Ready, 2002) Technical analysis has been a labeled a doubtful method according to many. Participants in the financial market as well as actors in the academic world have different opinions as to whether one could predict future prices by studying historical data.

How come it is so hard to find scientific studies regarding the adequacy of technical analysis? Why are there so many different opinions about this strategy without providing factual evidence? The fact that there are so many different opinions about whether technical analysis works and the lack of academic articles regarding the profitability of technical analysis along with the fact that it´s used frequently by participants in the financial market, is indeed interesting.
Some do support this method, others don´t due to lack of research and other significant data.
We are not aware of any study that applies trading rules such as moving average on Nasdaq Stockholm, thus this study fills a gap in our literature. The study provides a broad coverage of the Swedish market, more recent data and improved methodology than one prior study on that region.
The purpose of this study is to determine the efficiency of using moving average as a trading strategy when forecasting the direction of asset prices of companies listed on Nasdaq

Stockholm in order to exceed the buy-and-hold strategy. Focus will be on OMXS30[2], which is the 30 most traded companies on Nasdaq Stockholm.

1.5 Research question

Is it possible to accomplish a positive return on the Swedish stock market by using the technical analysis method and the moving average in particular as a trading strategy?

The hypothesis for this study are following:

H_0
$= The\ return\ for\ the\ buy\ and\ hold\ strategy\ equals\ the\ return\ from\ \ the\ moving\ averages$

H_a
$= The\ return\ for\ the\ buy\ and\ hold\ strategy\ does\ not\ equal\ the\ return\ for\ the\ moving\ average$

1.7 Delimitations

The following study intends to examine whether the technical analysis method and the moving average could maximize returns compared to the buy and hold strategy. The material that is intended to be studied is the 30 most traded stocks on Nasdaq Stockholm, OMX30 from 2003 to 2017. The main reason the study focus on Nasdaq Stockholm and not a foreign market is because the lack of research that is available on the Swedish market as well as that OMXS30 is a good representation of the Swedish market. The reason why we have chosen this time period is due to the fact that we strive to study as new data as possible. The moving average specifically is important because this is the most common technique in the technical analysis method. Furthermore, all transaction costs that are associated with trading will be excluded.

[2] A stock market index that contains the 30 most traded stocks on the Swedish stock market

2. Method

2.1 In general

The purpose of the study is to test whether technical analysis and the moving average in particular could generate higher return compared to the buy-and-hold method. The methods are applied on OMXS30 over a fifteen-years-old period.

2.2 Different scientific approaches

Positivism is derived from philosophic discussions about what science really are. The positivist believes that everything that can't be measured through empirical studies aren't science. Things like religion, feelings and values didn't belong to the scientific world. The main characteristics of the positivism is that there is a fundamental trust towards the scientific rationality. The knowledge should be empirical checkable estimates and assessments should be conducted through measurements. Supporters of positivism should always hold an objective stand to the examination subject.

Another approach is systems theory. Where system in this case means a group of objects that interacting. The theory focuses on subjects that can't be studied in laboratories because one factor can't be excluded from another one. The theory is more focused on social science where it is necessary to focus on several factors at the same time due to the interaction between them. A third approach is hermeneutics, this approach targeting the thing that positivism dismisses as irrational, namely religion, feeling and values. The focus is on interpreting these matters and a partial and holistic perspective.

The fourth approach is phenomenology, which focuses on empirical studies of human experiences and performances. The experience is always central. Generally, in teaching a positivistic way to learning result in rote learning while phenomenology way to learn is oriented towards the understanding of a subject.

In this thesis, the researchers mainly use a positivistic approach since the study is based on analyzing the OMXS30 index through using hypothesis. In order to achieve an applicable result, the researchers must have a neutral approach, which is what the positivism is about. The hermeneutics for example, this approach has similarities with the qualitative methods since both methods allow subjectivity. (Wallén, 1996)

2.3 Deductive versus inductive approach

There are two common approaches in science, the deductive and the inductive.

The starting point for the deductive approach is that the scientist assume that a certain theory is correct and then tries that theory against a result. In other words, the data is collected based on already available theories, and further tested whether it complies with the theories. This contrasts with the inductive way of examining a subject, where the theory is created out of the result. This implies that the empirical reality is tested through data that is not based on previous hypothesis, thus new theories and thoughts are being created. For this thesis, since the goal is to try already settled theory against empirical data, a deductive perspective is taken. (Wallén, 1996)

2.4 Quantitative versus qualitative

The general scientific investigation differs between two types of strategies when it comes to analysis of material. There are a quantitative and a qualitative method that the researcher can choose between. Both methods have their pros and cons. The qualitative method gives more information about fewer objects and the cons is that scientist tend to create a general picture based on studies on few objects. (Wallén, 1996)

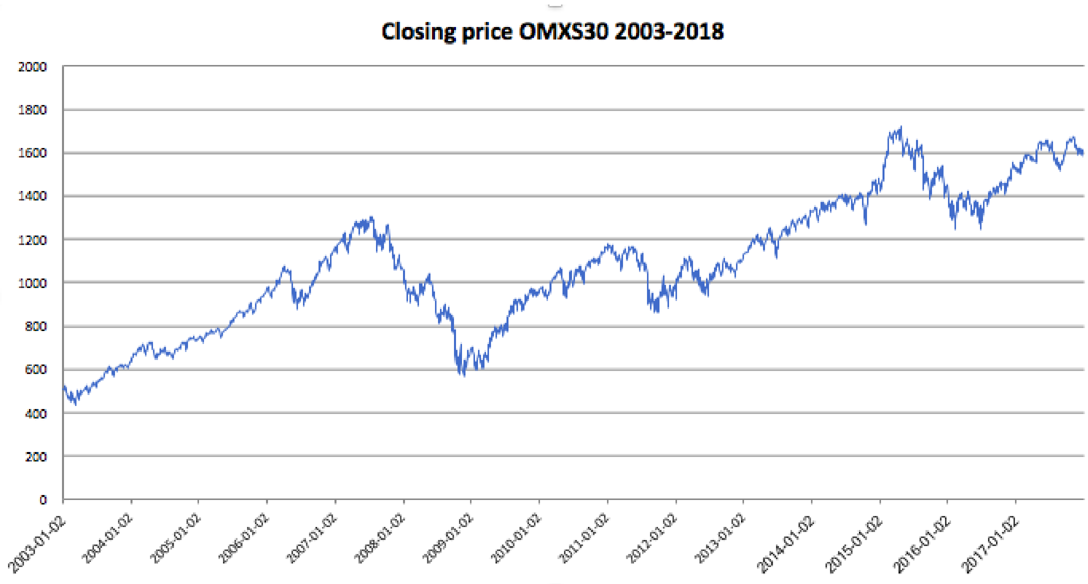
The quantitative analysis gives less information but include more observation. Its main focus is to investigate if there is causality and how common it is. (Wallén, 1996) A quantitative method focus on scientific objectiveness, different measurements and previous scientific researches, while a qualitative method doesn't have the neutrality in focus. The qualitative method also takes subjective approaches into account, which the quantitative doesn't. Since the aim of this study is to compare quantitative methods and since we are dealing with time series, a quantitative aspect is to prefer. In order to obtain a result that could be compared to previous researches, an objective approach is needed. The qualitative aspect would not be a good way to investigate if it is a causal relation with technical analysis and return over time. (Wallén, 1996)

2.5 Data collection

The data, which is the closing price of OMX Stockholm 30 Index, further only called OMXS30, was obtained from https://borsdata.se, a website which mainly provides data over the Swedish stock market. The data is on day-to-day basis and reaches from 2002-02-15 until 2017-12- 29. The investigation period is from 2003-01-02 to 2017-12-29, data from 2002 was needed though in order to calculate the moving average for the start of 2003. The data contains highest and lowest price for the day as well as open and closing price. Because of that fact, the researchers chose to always use the closing price.

There are two methods of collection, primary and secondary. Primary data is relatively more resource-intensive to use. This study is based on the closing price of OMXS30, previous researches and papers. Hence, we are only dealing with secondary data, but which we find reliable.

Figure 1.



Notes: Figure 1 shows the closing price of OMXS30 during the entire test period (2003-2018).

2.6 Data processing

The data processing was done through Excel and STATA 13. All the moving averages was calculated in Excel as well as buy and sell signals and the coding for holding. T-test, variance, standard deviation and mean values were conducted in Excel. Regressions, test of serial correlation and test of normality were done in STATA. The selection of the population wasn't needed because the observations in data were selected to fit the research topic. The reason why 2003-2018 is chosen is because it contains different trends in OMXS30 which able us to test the moving average in more and less volatile claimant. The data contains all the relevant observations that is needed.

2.7 Implementation of the process

The first part contained of gaining information of the subject. This turns up in the first part of the theory section were the theory behind moving average is described. In this literature, focus has been on previous results of the following moving average:

- MA1-50
- MA1-50 with percentage band at 1%
- MA1-150
- MA1-150 with percentage band at 1%
- MA1-200
- MA1-200 with percentage band at 1%
- MA5-150
- MA5-150 with percentage band at 1%
- MA2-200
- MA2-200 with percentage band at 1%

There are many different combination and variants of moving average and it would be practically impossible to implement and investigate all the different variants. Thus, these have been chosen since previous studies done on other regions, in which they claim significant better return than the buy and hold. The theory against moving average is the efficient market hypothesis which has as a starting point that the price trend follows a random walk. This was the second theory that the researchers studied.

Further, statistical test was needed in order to statistically secure the result that was studied. This all together created the theory section, which formed the null hypothesis that the buy and hold strategy gave equal return as the moving average.

Initially, data from borsdata was downloaded and imported into Excel. The generating process was mainly done in Excel, where the different moving averages was created initially. Further, the signals for each method was constructed. The formula for the signals can be found in appendix 3.

A buy signal was generated when an average that was less than its moving average yesterday is bigger than its moving average today and the convert for sell signals. The idea here is that whenever the averages crosses each other, a signal for a trade is generated. An investor starts with a starting capital off the market and holds it there until the trading method generate a buy signal, then all capital is invested at once. This implies that money is in the market, and at that moment, the investor doesn't react to anything else than a sell signal.

To implement this rule, a function that is called "holding" were created. Which simply disregards buy signals when the money is in the market, and disregard sell signals when the money is out of the market. Due to practicality trading fee and interest rate when the money is out of the market was omitted.

The percentage band which aim to reduce the amount of trades was implemented in the same way as the signal was, but with a slight correction which demanded the price to cross over with more than one percent or cross down lower than one percent in order for a signal to be generated. Both the code for holding and signal with band are in appendix 3. To calculate the return of the different methods, the return was calculated geometric and not logarithmic.
To be more specific over how the process worked in Excel, every time a buy signal was generated, the row for that day in the column for signals was given the number of “1” (buy). When a sell signal was generated a code with “-1” (sell) occurred.

All different kinds of moving average had their own columns for signal and holding. The geometric mean was calculated such as whenever there was a “1” in the holding section, the percentage development was recorded. When “-1” appeared, the geometric return for that day took the value of one, which indicate it is out of the market on an interest free account.

The aggregate return was calculated by taking take the product of the return for each day against each other.

Further, the mean value, standard deviation, variance and return was calculated for each method. The Students T-test was conducted due to dependence in our sample, and the goal with implementing t-statistic was to investigate if there is a statistically significant difference in return between buy and hold and the different moving averages.

Further, the sample were divided into three subsets with a number of years in each set in order to see whether we are able to find patterns that changed during the years. The reason why the sub periods were chosen is shown in table 1.

Table 1.

Sub period	Description
2003-2007	This period was just after the dotcom bubble crash, which affected the market. After the breaking point, the market started to rise again.
2007-2013	The main event that took place here was the financial banking crises which started in USA and affected the whole world.
2013-2018	The worst effects of the financial crisis are gone. Growth. Economic boom.

Notes: Table 1. Shows the characteristics of each sub period.

After gathering result for the moving averages in Excel, the efficient market hypothesis was tested in STATA. This was done through regressions on the Closing price. First checking if there was a trend in the variable by regress it against its lagged value. This gained the value for the auto regression. Further, Breusch-Godfrey test of serial correlation was conducted instead of the classic Durbin Watson test due to less sensitivity for unequal variance.

To check if the geometric return for each of the moving averages was normally distributed, which is required for the t-test to be unbiased, a test in STATA was conducted. It was conducted through histogram with the kdensity normal test. All the codes for the programming in STATA can be found in appendix 4.

With the results gathered from Excel and STATA, the analysis was done through a deductive approach, were theory were compared to a result and thereafter a rejection or non-rejection of the null hypothesis is done.

2.8 Shortcomings in the method

For this study to be practically possible some assumptions had to be done. First, dividends and delisting's are included in OMXS30 and the index adjust itself. One assumptions made in this study was that no interest was given during the period that the money was out of the market. Some of the moving averages stayed out of the market for years and as an investor accept to have the money out of the market with no interest for several years may not be very realistic.

The study also excludes trading fees which also isn't very realistic. For some of the strategies, over 100 trades were done, and to exclude trading fee in those cases may have a large impact on the outcome. The reason why both interest and trading fee were excluded were that they both have varied a lot over the year. Also since the aim was to avoid getting the return from interest together with the return from the trading strategy since it is the technical analysis that is in focus.

One other possible major lag of the trading strategy is that since data only exist in highest, lowest, closing and open price, price fluctuations during the day will be missed. It will be a late reaction to powerful movements in the price. Hypothetical, if the price in one stock drops from 100kr to 50kr during a day the sell will occur on the closing price if it is below the breaking point for the sell. Even though the breaking point may occur on 80kr. Since we don't have data that can measure that, the sell will be 30kr lower which can play an important rule. In a real-life scenario, an investor may react before the price continues to drop, which save a lot of money and effect the dividend received.

2.9 Validity and reliability

It´s crucial that scientific researches are done correctly, therefore two tools that aim to analyze what is studied are validity and reliability. Validity, which is the most important measurement tool in researches, is about to avoid systematic measurements errors. In other words, validity is a measurement of the safety of what a test is intended to measure. Validity is often divided into two aspects, external and internal validity. The internal validity is whether the theory is in line with what is measured. The external validity examines whether the findings of the study is in line with the actual world. The internal validity of this study is at a standard level, meaning that the method of this study is conducted as previous researches. The fact that this study is based on the closing price could affect the validity since it is not realistic that all trades are done at the closing price, which this study assumes. Further, previous researches have taken longer time periods into account, such as the study done by Brock, Lakonishok, and LeBaron (1992). They examined the moving average as a trading strategy on the Dow Jones Index from the first trading day in 1897 to the last trading day in 1986. The time period of fifteen years, in which this study is based on, is probably less valid than the study mentioned above.

Reliability is a measurement tool that describes the accuracy of a measurement and the absence of random measurements errors. A reliable method will generate the same result if repeated, regardless of who is performing. Theories that this study is based on, are mainly of prominent scientists in respective field, such as Fama (1970). Data have been checked with other sources, which confirm the reliability. In the light of this, although we are dealing with secondary data, we consider the reliability to be good.

3. Theoretical framework

3.1 Technical analysis

The technical analysis method branches into many different techniques, each of which attempt to forecast the price by studying the previous stock prices. The idea is that the market isn't completely efficient, hence the arbitrary of opportunities which can be detected by studying the shifts of supply and demand of stocks. Many of the techniques used today has been used for quite some time, some people even go further to say that the technical analysis method is the original form of investment analysis. But even with its reliable background, the attitude towards the technical analysis method in the academic world have been rather negative. However, recent studies still show a significant better return on investment using the technical analysis method compared to the simple buy-and-hold strategy (Bernhardsson, 2002).

The basic assumption of the technical analysis method is that history repeats itself, implying that the previous price pattern behaviors in stocks tend to recur in the future. Therefore, in order to predict stock market prices and essentially make profits, one has to be familiar with the previous price patterns and recognize the situations that is most likely to recur. (Fama, 1970) Contrary to the theory of random-walk, technical analysis theorizes that it is important to rely on the previous fluctuations of the stock market, implying that it is possible to make predictions regarding stock prices by studying the previous data. Essentially, these assumptions are strictly opposed and if the random-walk theory (see explanation below) holds as empirical evidence shows, technical analysis are nonsense. (Fama, 1970)

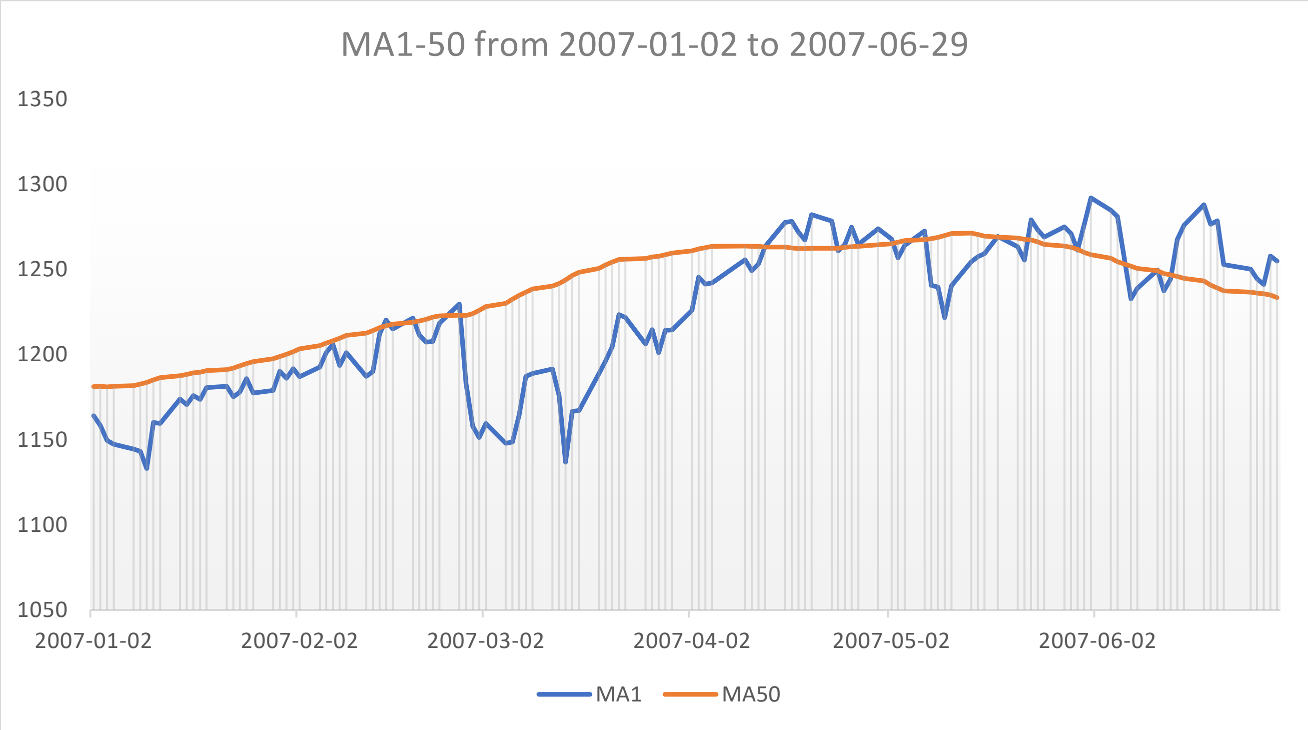
Although many factors such as assets and a company's P/E ratio heavily affects the market, the main function that affects the price of stocks are supply and demand. The market takes all these factors into consideration, rational as well as irrational factors, when setting a market price. Technical analysis differs from fundamental analysis in the sense that fundamental analysis only takes a company's ratio into consideration while technical analysis uses historical data. (Levy, 1966) Why Technical analysis is useful is because of the assumption that prices have trends and an identification of these trends is possible if studying past data and thus look for buy or sell signals that investors can follow. (Levy, 1966)
According to the efficient market hypothesis, this is theoretical impossible i.e. could not be predicted and abnormal returns are essentially impossible. The reason is because that the efficient market hypothesis states that prices reflects new information immediately and therefore all movements are random (Fama, 1970)
Previous studies that are done in this field show that the efficient market hypothesis is insufficient and that the market is not as efficient regarding the allocation of information as the efficient market hypothesis states. These studies are questioning whether the price of stocks really follow a random walk. These gaps are what enables excess returns compared to buy-and-hold, according to the supporters of technical analysis. (Brock et al, 1992)

3.2 Moving average

The mostly used technical rule is the moving average method. In accordance with this method, a trend is generated when the short- period moving average crosses the long period moving average of previous data of the security in question.
The longer and shorter moving average will generate signals, either a buy or sell signals, which an investor should essentially follow. The reason why the moving averages are useful is because they smooth out series that otherwise could be volatile. A buy signal is initiated when a short-

period moving average crosses a long-period moving average from the below and a sell signal is initiated when a short-period moving average crosses a long-period moving average from above. (Brock et al, 1992)

Figure 2.



Notes: Figure 2. shows how buy and sell signals are generated by dint the short-period moving average and the long-period moving-average. When a short-period moving average crosses a long-period moving average, a trend is being initiated.

The most commonly used moving average is 1-200, where the short-period is one day and the long-period moving average by 200 days. (Brock et al, 1992) This technique is often modified with a band that reduces the numbers of buy and sell-signals by eliminating "whiplash" signals. "Whiplash" signals are generated when short and long period moving averages are close. The band that is used around the long-period moving average makes it possible to eliminate fast fluctuations. Fast fluctuations generate several signals during a short period of time. This implies that no signals will be generated if the short-period moving average is within the band. The band could be set to a range of one percent, which is a range used in all previous researches. (Brock et al, 1992)

A moving average is being computed as follows:

$$\frac{P_{t+}P_{t-1} + \cdots + P_{t-(n-1)}}{n}$$

Where:

$$P_t = the\ value\ of\ the\ closing\ price\ of\ OMXS30\ at\ time\ t.$$
$$n = the\ number\ of\ days\ of\ the\ moving\ average\ period.$$

The moving average technique is an objective method compared to other methods included in technical analysis. It is an objective technique in the sense that an investor buys and sells according to the rules that the moving average is based on. Other techniques included in technical analysis imply subjective interpretation (e.g. such as graphs), where investors make different interpretation regarding buy-and-sell signals and therefore acts differently. (Acar & satchell, 1997)

3.2.1 Students T-test

In this thesis, Students T-test is used in order to statistically secure the result generated from the moving average method, which is important when we compare the buy and hold to the different kinds of moving averages. The t-test is a so-called Student's T-test which is a t-test designed for dependent groups. The formula for the test is:

$$t = \frac{\sum D / N}{\sqrt{\frac{\sum D^2 - \left(\frac{\sum (D)^2}{N}\right)}{(N-1)(N)}}}$$

$t = t_{obs}$
N= Observations
$\sum D$= Sum of the differences
$\sum D^2$= Sum of the squared differences
$(\sum D)^2$ = Sum of the differences squared

3.3 The efficient market hypothesis

The definition of an efficient market is a place where market participant actively competes in order to maximize their profits. The participants are constantly trying to forecast the market values, which is possible due to the information available. This will eventually lead to the prices of securities at any time which will reflect on all the available information in the market, both current and expected information. Thus, the current price of a security is a good prediction of its intrinsic value (Fama, 1970).

The efficient market hypothesis was initially presented by Fama (1970). The efficient market hypothesis states that prices in the market always reflects the available information. According to this theory, an effective market is a market where new information adjusts the prices immediately, implying that the current prices already reflects all new information available. This also implies that the only thing that will affect the stock prices is new information. Since information is unpredictable and given randomly, this theory states that prices of securities move randomly, like a random walk (Fama, 1970).

Fama (1970) presents three conditions for an efficient market where the price will always reflect available information in such market.

1. There are no transactions costs in trading securities.
2. All available information must be available for all participants at no cost.
3. All participants agree about the implications of current information and for the current price of each security.

Furthermore, Fama (1970) says that these frictionless markets in which all the information is available and were actors in the market interpret information differently, is not met in practice. (Fama, 1970). Fortunately, the conditions mentioned above are sufficient for an efficient market, but they are not necessarily met. Market price will reflect all available information even though there are high transaction costs and even though not every actor in the market interprets new information in same way.

3.4 Random Walk hypothesis – An extension of the efficient market hypothesis

During the introduction of the efficient market hypothesis, Fama (1970) assumed that the price of the security in question was fully reflected by all available information and changes in prices will only occur if new information is generated. Furthermore, this implied that successive changes in prices are independent of each other as well as they are identically distributed. In the light of this, the successive changes in price occurs randomly, according to the random walk hypothesis. These two assumption gives us the random walk hypothesis.

To understand what Fama (1970) meant when he referred to the price development as a random walk it is necessary to give a brief explanation of what a random walk is, how to test for it, what the test contains and how to interpret the results.

Before continuing with explaining the random walk, some few statistics which is going to be referred to needs to be explained.

First off is the Gauss-Markov Assumptions in time series. To run a regular regression model like:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t + u_t$$

There need to be certain assumptions made to ensure that the beta-coefficient is not biased. These assumptions are the following:

Gauss-Markov Assumptions in time-series

In cross-section samples, a variable x is exogenous if each observation in the sample have to be independent of every other observation.

In the time-series, observation that are close each other regarding time are likely to be related. The strict exogenity assumption $E\left(\varepsilon_t \middle| \dots, x_{t+2,} x_{t+1}, x_t, x_{t-1} \dots\right) = 0$, which requires the regressors value in period t to be unrelated to the error term in every period.

In order to apply the Gauss-Markov theorem to a time-series, following assumption have to be met:

1. Linear Model: the data-generating process of y, x2…,xk is
   $y_t = \beta_1 + \beta_2 x_{t,2} + \dots + \beta_k x_{t,K} + u_t$ t=1,2…T, Where u_t *is a sequence of error*

2. Strict exogenity: The explanatory x are strictly exogenous with respect to the error term.

$$E(u_t|X) = 0, t = 1, 2, \dots, T,$$

3. No perfect collinearity: No regressor x is constant and cannot be expressed as a linear function of other regressors.
4. Homoskedasticity: Conditional variance of u_t *is constant*:

$$var(u_t|X) = \sigma^2, t = 1, 2, \dots, T.$$

5. *No serial correlation*: *The error terms are not correlated.*

$$cov(u_{t,} u_{t-s}|X) = 0, s = 1,2, \dots, T - 1$$

5. The error terms are normally distributed

Following statistical concept is also necessary to briefly understand for the reader:

P-value: is often used in statistical tests when testing if one could reject the hypothesis or not. The p-value could be considered as a tool of measurement when checking if a nullhypothesis is true. A low value indicates less probability that the null hypothesis is true, and the opposite. A high p-value indicates low probability that the null hypothesis is false.

Autocorrelation is a value of the correlation between a time serie and a lagged version of the same time serie. It measure the relationship between the current value of a variable and the past value of the same variable. The value could be from a range of -1 to 1. Where 0 implies no correlation at all and a value of 1 indicates unit root

3.4.1 Random walk with drift & random walk without drift

In econometrics scientists divide data in to three parts, cross-sectional, time series and panel data. As a short explanation, cross-sectional data is when comparing different individuals in one point in time, time series data is comparing the same individual at several points in time. In cross-sectional data, there is a sample drawn which is used to draw conclusions about the population. In time series data, there is realization of a process. Realizations are the sample of the time series since the time series is a process and will continue in the future. (Gujarati & Porter, 2009)

With time series, there is important to distinguish between a nonstationary stochastic process and a stationary stochastic process. Random walk is a synonym for nonstationary stochastic process, so there will be more focus on that part.

First a short explanation of a stationary process. For a time series to be stationary it need to add up to the following criterions:

1. Mean reversion: $E(Y_t) = \mu$
2. Constant amplitude (same thing as constant variance): $Var(Y_t) = E(Y_t - \mu)^2 = \sigma^2$
3. Covariance: $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$ (Gujarati & Porter, 2009)

This means that the mean and the variance needs to be constant over time so the pattern in the time series will repeat itself. Variable γ_k is the covariance at lag *k*. This measure the covariance between the values at Y_t and Y_{t+k}, so the covariance between two Y values with k periods apart. These conditions say that the covariance is only allowed to depend on the distance between two time periods and not the actual time at which the covariance is computed. (Gujarati & Porter, 2009) The time series need to have certain characteristics which make it able to forecast. The reason to this is that when there is a nonstationary process there is only possible to study the past observations since the next observation is going to be completely random. Thus, it is not possible to generalize it to other periods. (Gujarati & Porter, 2009)

A nonstationary process implies that forecasting is not possible. As earlier mentioned, random walk is a synonym to nonstationary processes. The random walk needs to be split up in to two sections though, random walk without drift and random walk with drift. (Gujarati & Porter, 2009) Random walk without drift has the following mathematical description:

$$Y_t = Y_{t-1} + u_t$$

Where: u_t is the error term and Y is the actual value that is measured. The subscript t stands for time and t-1 stands for the value of Y for the previous period, or "lagged" period. In this thesis, the word lag/lagged will be repeatedly used, and it refers to a previous value. (Gujarati & Porter, 2009)

That can be rewritten as:

$Y_t = Y_{t-1} + u_t$

Which enable the following derivation:

$Y_1 = Y_0 + u_0 => Y_2 = Y_1 + u_2 = Y_0 + u_1 + u_2 => Y_t = Y_0 + \sum u_t$

Since Y_0 are assumed to be zero the part of $\sum u_t$ controls the process. That part is called the stochastic process. Since it contains the sum of the random error terms a shock in u_t persist through all continuous time periods. (Gujarati & Porter, 2009)

Random walk without drift has the following mean and variance:

Mean = $Y_0 = 0$

$Var(Y_t) = t\sigma^2$

(Gujarati & Porter, 2009)

Y_0 is assumed to be zero which indicates constant mean. The variance though is dependent on the variable t, which makes the variance nonstationary. With this process, since the mean is assumed to be zero, the part of $\sum u_t$ is the stochastic process. (Gujarati & Porter, 2009)

Random walk with drift has the following mathematical description:

$Y_t = \delta + Y_{t-1} + \mu_t$

Where δ which is the intercept that becomes the drift parameter. If δ has a positive value then we have a drift upward, a negative value implies a drift downward. The mathematics behind is the same as the mathematics behind random walk without drift. (Gujarati & Porter, 2009)

Thus, the random walk with drift has the following mean and variance:

Mean = $Y_0 + t\delta$

$Var(Y_t) = t\sigma^2$

Thus, none of them are constant over time since both are dependent on the variable t. The random walk with drift compered to random walk without drift has an underlying drift parameter which gives it a direction. That's is what is meant with drift in this case, even though the time series is random, it has an underlying direction. (Gujarati & Porter, 2009)

3.4.2 Deterministic trend versus stochastic trend

Furthermore, a distinction between a stochastic and deterministic trend needs to be done. If the dependent variable is a function of time, there is a deterministic trend which can be predicted. If it is a stochastic trend then it is not predictable.

Consider the following models: (Gujarati & Porter, 2009)

$Y_t = \beta_0 + \beta_1 t + \beta_2 Y_{t-1} + u_t$

Where β_0 is the intercept term. And β_1 and β_2 are the slope coefficients which measure the effect of time respectively the lagged dependent variable, on the dependent variable. u_t is the white noise error term, which is an error term that occur when regressing a variable against itself lagged. Such regression is called autoregression, in the equation, there is a AR(1) process since it is lagged against its latest value. The white noise error term always occur in case of Autoregression and the white noise error term assumes to satisfy the standard OLS assumptions. (Gujarati & Porter, 2009)
Pure random walk occurs when β_0=0, β_1=0 and β_2=1 since it gives the following equation:
$Y_t = Y_{t-1} + u_t$
The equation above is a random walk without drift, which is a nonstationary process. (Gujarati & Porter, 2009)

Random walk with drift occurs when $\beta_0 \neq 0$, β_1=0 and β_2=1 since it gives the following equation:
$Y_t = \beta_0 + Y_{t-1} + \mu_t$
Where β_0 replace δ, but both mean the same thing. β_0 is the drift variable that creates a trend. Such trend is called a stochastic trend. (Gujarati & Porter, 2009)

Deterministic trend occurs when $\beta_0 \neq 0$, $\beta_1 \neq 0$ and β_2=0 since it gives the following equation:
$Y_t = \beta_0 + \beta_1 t + \mu_t$
This is called a trend stationary process, with a mean of $Y_t = \beta_0 + \beta_1 t$ and a variance of σ^2. Even though the mean is not constant, it can be perfectly forecast when the values of β_0 and β_1 are known. (Gujarati & Porter, 2009)

Random walk with drift and deterministic trend occurs when $\beta_0 \neq 0$, $\beta_1 \neq 0$ and β_2=1 since it gives the following equation:
$Y_t = \beta_0 + \beta_1 t + \beta_2 Y_{t-1} + u_t$ (Gujarati & Porter, 2009)

It is important to distinguish between these different processes since it gives four different types of time series which looks rather different. (Gujarati & Porter, 2009)

In econometrics, there are several test conducted to determine what type of these four time series that is occurring. They will be described in short in chronological order with respect to what order they will be tested in the result. The order follows the usual approach for testing if a time series is a random walk. (Gujarati & Porter, 2009)
The regression analysis that the following tests are conducted on is:

$$Y_t = \beta_0 + \beta_1 t + \beta_2 Y_{t-1} + u_t$$

3.4.3 Tests of stationarity

Auto regression on error terms shows if the lagged error term has a significant effect in the error term today. The formula is following:
$u_t = \rho u_{t-1} + \varepsilon_t \qquad -1 \leq \rho \leq 1$

If ρ is close to one, then the error term today is almost completely dependent on the error term of the lagged period. Since the t-test which is usually conducted to decide if a coefficient is significant or not, the **Durbin-Watson d Test** is conducted.
The Durbin-Watson d Test can be summarized to the following equation:
$d \approx 2(1-\rho)$ (Gujarati & Porter, 2009)

The test is thus a test for autocorrelation. It tests whether the coefficient ρ is significant different from zero. Since the test does not follow any of the common distributions in statistics such as F, t or χ^2 but the creators of the test, Durbin and Watson was successful in deriving an upper and lower bound. These limits are called d_L and d_U where subscript L=lower and U=upper. (Gujarati & Porter, 2009) The test has the null hypothesis that d=2, hence$\rho = 2$. If the d-value received using the estimated ρ from the Durbin-Watson d Test is greater than d_U i.e close to four then ρ is significant negative. If it is significant lower than d_L i.e close to zero then ρ is significant positive. In any of these two cases, the regression suffers from autocorrelation. The disadvantage the Durbin-Watson d Test is that is relies on that the explanatory variables are non-stochastic which can be hard to test, it is not allowed to have lagged values of the regressad among the regressors and it can only test the autocorrelation for one lag back in time. (Gujarati & Porter, 2009)

Thus **Breusch-Godfrey Test** of autocorrelation is done in order to complement the Durbin-Watson d Test. The Breusch-Godfrey is a more general test and does not suffer from the same disadvantages as the Durbin-Watson d Test. Hence, the autoregression can contain more than just AR(1), it can contain AR(p) lags in the regression. The test follows a χ^2 distribution and the formula for it is: $(n-p)R^2 \sim \chi^2$
Where n=number of observations, p=number of lags and R^2=explanatory factor which loosely can be used to evaluate how good our model fit. The Value from $(n-p)R^2$ is then compared to the critical value of χ^2. (Gujarati & Porter, 2009)

Graphical analysis gives an intuition of what the series looks like. As shown earlier in the graphs, the different processes look rather different. (Gujarati & Porter, 2009)

Autocorrelation function and Correlogram, the use the following formula to calculate the autocorrelation coefficient:

$$\rho_k = \frac{\gamma_k}{\gamma_0} = \frac{Covariance\ at\ lag\ k}{Variance}$$

$\gamma_0 = Varinace$ since covariance: $\gamma_0 = E[(Y_t - \mu)(Y_{t+k} - \mu)]$ =$E[(Y_t - \mu)(Y_{t+0} - \mu)]$
= $E[(Y_t - \mu)(Y_t - \mu)]$ = $E(Y_t - \mu)^2$=σ^2(Gujarati & Porter, 2009)

σ^2 is the coefficient of variance. Conducting this test in STATA provides a figure with two columns of autocorrelation. In Appendix 6. from the result, a picture from such table is shown. Intuitive, one can see if the autocorrelation starts at a high value and the slowly declines towards zero the time series probably are nonstationary. (Gujarati & Porter, 2009)
To conduct if a certain coefficient is significant or not, two other tests are conducted. Namely Box and Pierce Q statistics, which approximately follows a χ^2 distribution and Ljung-Box test statistic which also follows a χ^2 distribution. (Gujarati & Porter, 2009)

The formula for Box and Pierce Q statistic is:

$$Q = n \sum_{k=1}^{m} \rho_k^2$$

Where n=number of observations, m= lag length and ρ is the value of the autocorrelation at the m:th lag. The value obtained are then compared to the critical χ^2 with m degrees of freedom. (Gujarati & Porter, 2009)

The Ljung-Box statistic use a similar formula:

$$LB = n(n+2)\sum_{k=1}^{m}\left(\frac{\rho_k^2}{n-k}\right)$$

This test is also compared to the critical χ^2 with m degrees of freedom. The only difference is that LB are more powerful in small samples than Q statistic, but that is a topic beyond the scope of this thesis. Both tests, test the joint hypothesis that all ρ_k up to a certain lag are simultaneously equal to zero. There is possible to test every single lag as well but that is nothing that are conduct in this thesis. (Gujarati & Porter, 2009)

As an alternative to the correlogram, it is possible to do a test called, **The Unit Root Test**. Formula for this test is:

$$Y_t = \rho Y_{t-1} + u_t$$

Where u_t is a white noise error term. If $\rho = 1$ then there is a unit root. It also creates the formula of a random walk without drift, which is a nonstationary process. The formula can be manipulated to the following: (Gujarati & Porter, 2009)
$Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + u_t = \Delta Y_t = \delta Y_{t-1} + u_t$, where $\delta = (\rho - 1)$

To test if the coefficient i.e. the value of δ is signfiant different from zero, a test called Dickey-Fuller is conducted. The test follows τ statistics and provides an observed value and a critical value. The null hypothesis is that δ is equal to zero, hence if the null hypothesis cannot be rejected, then there is a possibility of unit root. (Gujarati & Porter, 2009)
To allow for the possibility that it can be a random walk with drift, random walk without drift or random walk with drift around a deterministic trend the Dickey-Fuller test is estimated under three different null hypotheses including the formula for all of these three. (Gujarati & Porter, 2009)
The hypothesis is:
Null hypothesis: $H_0: \delta = 0$ => there is a stochastic trend (random walk with drift) or a nonstationary process (random walk without drift). (Gujarati & Porter, 2009)
Alternative hypothesis: $H_0: \delta < 0$ => stationary time series, possibly around a deterministic trend. One downside with the test is that it relies on that u_t, is uncorrelated. There is also a nonparametric similar test, called **Philips-Perron** that neither depends on no serial correlation in the error term. (Gujarati & Porter, 2009)

3.6 Previous work

Brock, Lakonishok, and LeBaron (1992) examined the moving average as a trading strategy on the Dow Jones Index from the first trading day in 1897 to the last trading day in 1986. The authors are examining whether the technical analysis method and the moving average in particular actually works; even though many studies shows that technical analysis is useless. According to the moving average rule, the researchers used long-period average and short-period average, which were 1-50, 1-150, 5-150, 1-200 and 2-200. Brock, Lakonishok, and LeBaron (1992) acted according to the signals; they bought or sold securities when the short-period moving average raised above or felled below the long-period moving average. A comparison between the returns of this technique to the actual Dow Jones series were made. Support for the moving average were revealed, were signals from the moving average turned out to generate higher returns compared to “normal” returns. The annual buy return when using the moving average method was 12 % and the majority of the two-tailed tests rejected the null hypothesis of equal returns at a 5 percent significance level. The annual sell return was -7 % and all of the two-tailed tests rejected the null hypothesis of equal returns. The researchers proved that following a buy signal, returns are significantly less volatile than following a sell signal. However, the authors emphasize that transaction costs were not taken into consideration, which according to them could greatly affect the results and thus also the profitability of this technique. (Brock et al, 1992)

Pang-Wen Ling (2011) compares different techniques such as the moving average method and the fractal method as a trading strategies on the Taiwanese market. The aim with the study was to compare technical analysis strategies regarding of how accurate they are when predicting stock price behavior. The study utilized these models during two periods, 11 trading days from April 1 to 16, 2002, and 11 trading days from April 1 to 16, 2008. The study was based on the stocks of three of the largest companies in the Taiwanese market. The conclusion of this study is that the moving average is easy to apply but if applied on its own as a prediction method, it will not be the best method regarding accuracy. The moving average is considered weak regarding the predicting price behavior. It's recommended to combine other methods included in technical analysis with moving average in order to predict actual stock prices behavior. The moving average is suitable and an accurate method if it is applied on stocks with small changes in long term (Ling, 2011).

Ratner and Leal (1999) examines the “tests of technical trading strategies in the emerging equity markets of Latin America and Asia” the return of 10 markets in Latin America and Asia from Januari 1982 to April 1995 using moving average. The return of these markets after counting off trading costs and using the moving average are compared to a buy-and-hold strategy. The authors have adjusted the returns for inflation, since many of the countries in this study show high level of inflation. The study shows that technical trading strategies are correct when predicting the movements of the market when ignoring statistical significance. This study also shows that less trades were conducted when the authors used a trading band. Using the moving average without a trading band generates a huge amount of buy and sell signals and therefore causes a big amount of trades will be conducted. The study proves that in most cases, using the moving average generates higher returns compared to using the buy and hold method. This is only true if transactions costs are not taken into consideration.

4. Results

The hypothesis for the test are following:

$$H_0 = The\ return\ for\ the\ buy\ and\ hold\ strategy\ equals\ the\ return\ from\ \ the\ moving\ averages$$

$$H_a = The\ return\ for\ the\ buy\ and\ hold\ strategy\ does\ not\ equal\ the\ return\ for\ the\ moving\ average$$

4.1 Result for Moving Average

The following table present the return from the different trading strategies. The total period is 2003-2018 which is divided in to three sub periods, 2003-2007, 2007-2013 and 2013-2018. The sub period always goes form the first trading day of OMXS30 for the year to the first trading day for the year for the finishing year of the period. Below the test column the different kinds of moving average are represented. Further, the number of buy and sell signals are measured. It is a consistent result that the shorter moving average generate more buy and sell signals than the longer ones. The percentage decreases for the buy and sell signals as well, but it's arbitrary depending on which moving average.

The column Total R represent the total return during the period. The moving average 5-150 with band generated the best return. Column 6-8 shows the return during each sub period, where it shows that MA5-150 outperformed all the other strategies during the more volatile period between 2007-2013.

Table 2. The performance of the moving average compared to the buy-and-hold method.

Period	**Test: MA**	**N(buy)**	**N(sell)**	**Total R**	**R(03-07)**	**R(07-13)**	**R(13-18)**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
2003-2018	1-50	128	128	1,6023	1,6770	0,96593	0,9891
	1-50, 1%	158	126	1,5579	1,5389	0,99626	1,0161
	1-150	65	65	2,4654	1,7563	1,0827	1,2965
	1-150, 1%	64	60	2,7448	2,0049	1,0554	1,2970
	1-200	45	45	2,6177	1,7894	1,0762	1,3591
	1-200, 1%	56	41	2,9346	1,8333	1,2130	1,3195
	5-150	28	21	3,3205	1,9799	1,3789	1,2161
	5-150, 1%	27	21	3,4227	2,0152	1,3406	1,2668
	2-200	38	38	2,7954	1,8089	1,2398	1,2464
	2-200, 1%	36	33	2,9348	1,8201	1,2387	1,3016
	Test: BnH			3,1973	2,3261	0,9849	1,3955

Notes: table 2. shows the return of the different moving averages, both with a band and without a band as well as the return of the sub periods.

What is consistent during the whole period is that the standard deviation is lower for all off the different trading methods compared to buy and hold.

The t-test which test the null hypothesis that there is no significant different in return between the buy and hold strategy and the different variants of moving average is non-significant for all off the different trading strategies. The alpha values were set to 0, 05 but even with alpha set to 0, 10 the same result from the t-test was received (see appendix 3).

The result show that most of the trading strategy perceive signals about a negative trend during the period 2007-2009. This can be seen in table 2. where 9/10 of the strategies outperform the buy and hold strategy.
All the t-test and test for normality as well as the mean, standard deviation and the variance for each method are represented in the appendix. Appendix 1. shows the distribution curve for each trading strategy, appendix 3. shows all the t-test in its full extent where every trading strategy is compared to buy and hold. Appendix 3. shows all the mean, standard deviation and the variance for each method.

4.2 Test of Random walk

The result for the first regression shows highly significant upward trend.

Table 3. OLS estimate of Date effect on Closing price on day to day basis.

Date	0,24188**
	(108,54)
Intercept	615,4329**
	(124,41)
R2	0,7566
Number of observations	3792

*Notes:The dependent value close price is expressed in terms of SEK. T-values in parenthesis. *=p<0,05, **=p<0,01*

Durbin-Watson d-test shows a value close to zero which is far below d_L which reject the null hypothesis of none autocorrelation among error terms.

$$Durbin - Watson\ d - test(\ 2, 3792\ ) = 0{,}0080767$$

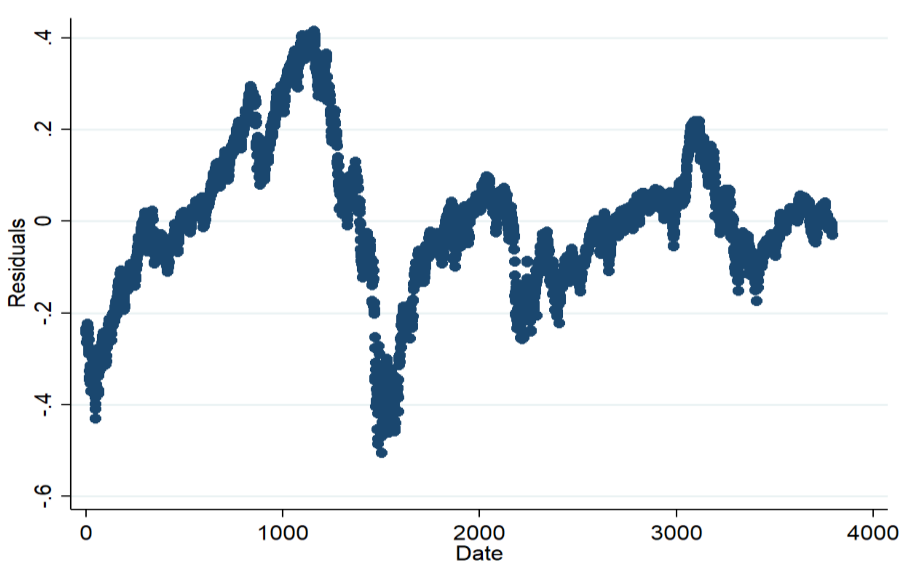
The Breusch-Godfrey test gives a 0, 0000 chance that the error term does not suffer from autocorrelation.

Table 4. Breusch-Godfrey BG test for autocorrelation

Lags(p)	Chi2	df	Prob>chi2
1	17,224**	1	0,0000

*Notes: Observed chi2 is compared to the critical chi2 that is in parenthesis. *=p<0,05, **=p<0,01*

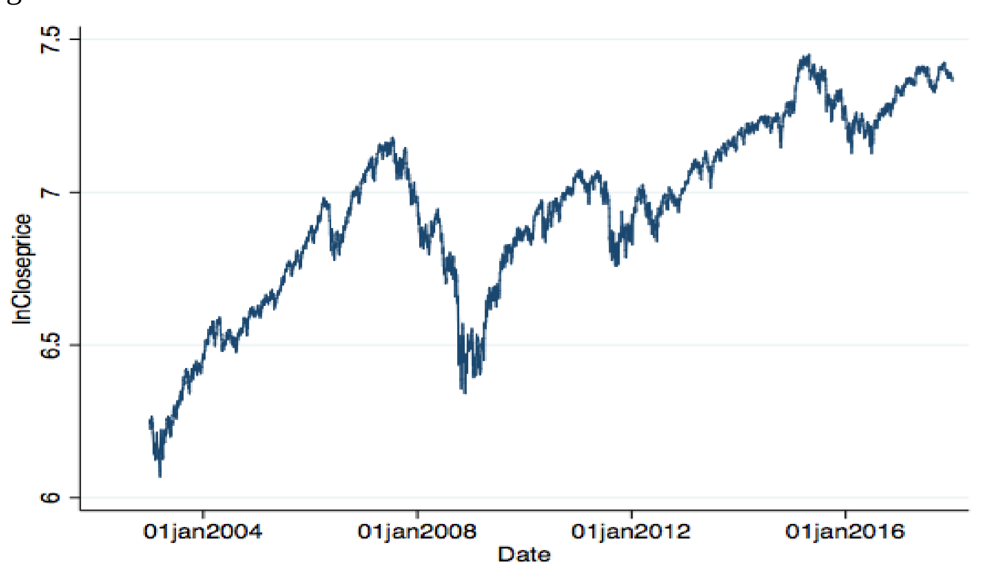
Figure 3.



Notes: Figure 3. Illustrates the autocorrelation due to a cyclic pattern.

Since error terms that are autocorrelated often indicates that the process is nonstationary, continued test for random walk are warranted. First test is a graphical test.

Figure 4.



Notes: Figure 4. Illustrates the logarithmic closing price of OMXS30 during the test period.

The graphical picture over the data looks like a random walk with drift. Hence a continued look over the sample correlogram is conducted. The correlogram that can be found in appendix 6, show a classic example of a series that is nonstationary. The Q-statistics developed by Ljung-Box gives a probability of 0, 0000 that none of the *p* are significant different from zero:

Table 5. Portmanteau test for white noise

Portmanteau (Q) statistic	1.422e+05**
Prob>$\chi^2(40)$	0,0000

*Notes: *=p<0,05, **=p<0,01*

When regressing the following model for the logarithmic Closing price:
$\Delta Y_t = \delta Y_{t-1} + u_t$,

And then conducting Breusch-Godfrey on that, the following result was obtained:

Table 6. Breusch-Godfrey BG test for autocorrelation

Lags(p)	Chi2	df	Prob>chi2
1	12,293**	1	0,0005

*Notes: Observed chi2 is compared to the critical chi2 that is in parenthesis. *=p<0, 05, **=p<0, 01*

Since the white noise error term suffer from autocorrelation the Dickey-Fuller test will be biased, so the similar nonparametric Philips-Perron test was conducted. The null hypothesis is that there is a random walk with drift. The observed value is far below their critical value and the p-value obtained are at 0, 3. The critical values are gathered from the τ statistics.

Table 7. Philips-Perron test of random walk without d

Z(rho)	-11,732
	(-18,300)
Z(t)	-2,554
	(-3,120)
Mackinnon approximate p-value for Z(t)	0,3017
Number of observations	3791

Notes: Critical value in the parenthesis is at 10%.

5. Analysis

This study has shown that using technical analysis, and the moving average as a trading strategy on the Swedish stock market will generate lower return on average. This is true especially compared to the passive buy-and-hold strategy. The buy-and-hold method has generated approximately 3,2 times the starting capital during the years that this study has been conducted. The only trading strategy that has generated higher returns is the moving average with the periods 5-150 and the moving average 5-150 used with a percentage band. As shown in the result, all other strategies have generated as less than the passive buy-and hold method. For example, the moving average with time periods 1-50 has generated mostly lower returns, as well as with a band, compared to the buy-and-hold method. The moving average method 5-20 is the only strategy that appeared to be statistical significant. The majority of the methods that have been tested appear to be in line with the efficient market hypothesis and the random walk hypothesis. The study also proves that using the moving average method with and without a band cannot be used to identify market trends and essentially positions such as buy-and-sell signals. This finding seems to be in accordance with the efficient market hypothesis and the random walk hypothesis that states that the past history of a stock price/market cannot be used to predict future movements (Fama, 1970).

This study proves that the buy-and-hold strategy has in the majority exceeded the technical analysis and the moving average method in particular. As Fama (1970) states, no active trading strategy can be used to overcome the buy-and-hold strategy, which is a passive trading strategy. Thus, this result is according to the efficient market hypothesis that states that prices in the market always reflects the available information. New information will adjust the prices immediately, which confirms that the price will be correct at any time. Using active trading strategies to predict future prices will not be possible since information is unpredictable and given randomly. This is in line with this study’s findings. Using an active trading strategy, such as the moving average in this case, will not generate returns that exceed the buy-and-hold strategy. The reason of this finding could be that the prices of securities move randomly, as the efficient market hypothesis states (Fama, 1970).

This study has not included transaction costs in the analysis, which could be a reason to this result that is in line with the efficient market hypothesis. Ratner and Leal (1999) examines the return of 10 markets in Latin America and Asia from January 1982 to April 1995 using the moving average. They included the transaction costs in their study and concluded that the moving average generates higher returns compared to using the buy and hold method. This is especially true if transactions costs are not taken into consideration. The study shows that the profitability of using the moving average method is limited if transaction costs are taken into account. Ratner and Leal´s conclusion is not in line with the findings in this study. But as mentioned, this study has excluded transaction costs and therefore we cannot prove that would have been the case if we included transaction costs. Transaction cost is an important factor to take in consideration when applying technical analysis and the moving average in particular since the number of signals means increased costs and essentially causing more expensive trades, which could affect the returns.

The majority of the findings seem to be consistent with the random walk hypothesis, which is an extension of the efficient market hypothesis. The Random walk hypothesis states that changes prices were assumed to be identically allocated between negative and positive changes, which occurs randomly. A random walk suggests that the past history of a stock price/market cannot be used to predict future movements. Simply, the movements of the securities are random and unpredictable. (Fama, 1970) All the methods show positive return between 2003 and 2007, but no one of the methods have a return that exceeds the buy-and-hold strategy, which also appears to be consistent with the efficient market hypothesis and the Random walk hypothesis. This finding is in line with the test of random walk that we have done. We can prove that the autocorrelation of the price is almost one and statistical significant, which implies that the price follows a Random walk. A random walk suggests that the past history of a stock price/market cannot be used to predict future movements. The price movements of the securities are random and unpredictable. (Fama, 1970)

During 2007-2013 all moving average methods except 1-50 with both a band and without a band appeared to exceed the buy-and-hold strategy. This finding is interesting since it is not consistent with either the efficient market hypothesis or the random walk hypothesis. That the majority of the methods were not consistent with the theories mentioned above between 2007-2013, could speculatively be due to the financial crisis. A possible conclusion to this could be that passive strategies, i.e. buy-and-hold does not do as good as active strategies, such as the moving average under crisis. This study does not examine technical analysis under different market conditions such as financial crisis, and therefore we do not have enough evidence to state that this is the case. The standard deviations for all technical analysis methods are lower consistently compared to buy-and-hold method. This indicates that investors will achieve safer trade using technical analysis and moving average in particular since this method is less volatile, compared to the buy-and-hold method.

6. Conclusion

The purpose of this study was to first determine if it is possible to generate statistical significant better return with help of moving average as an indicator when to be in the market and when to be out of the market. The object for this study was OMXS30, which was studied over the last fifteen years. The result from the method of moving average was quite different depending on which moving average that were used. Only two of ten generated higher return than the buy and hold strategy though. But it was not significant better. The different moving averages performed better than buy and hold during the more volatile period, and in general, all of them had lower standard deviation which indicates lower risk. The result is in contrast to what the theory based on the article from Brock(1992) states in the theory section. The comparison might not be completely fair though since the research period for this essay is much shorter. There is also two different index used, and there might be the case that the trading strategy perform different depending on which index that are investigated. Another important point to add here is the fact that when the capital is out of the market, then it is assumed to be on an interest free account, which might not be very realistic. There is also the case, since the buys and sells are based on the closing price, that dramatic changes in price follows up with a slow reaction. It was not possible to gather second to second data, and if it was the case that it was possible to gather more precise data, then maybe the result would be rather different. At the same time, there is important to mention that trading fee also were excluded. Something that also Brock(1992) did in their research. They conducted later that if trading fee was taken in to account, then the significant result they gathered would be much less significant. At some point the researchers hope these external factors will exclude each other, but that might be rather naive.

The opposite theory of the technical analysis is Fama(1970) that presented the efficient market hypothesis(EMH). EMH suggest that the market price always reflect all the available and relevant information on the market at the moment. Fama equated this market condition with random walk. The theory of a random walk is that there is no pattern in a time series which make it impossible to forecast. In our case, the close price of OMXS30 should be impossible to forecast if it follows a random walk. The tests conducted to explore if the time series containing the close price for OMXS30 was a random walk, pointed clearly on a random walk with drift. In other words, the process seems to move rather random but with an underlying drift upward. The underlying drift is probably GDP and or inflation. But the movement along the drift follows the properties for a random walk. That result is in line with what Fama(1970) concluded. Hence, OMXS30 should be impossible to forecast with historical data over the prices. Which it seemed to be in the case of moving average however.

Both of these results point in the same direction. Namely, the price development of OMXS30 is rather random. That is supported with the poor return gathered from the moving average trading techniques and the result from the test for nonstationary. To answer the research question: On OMXS30, there was not possible to conduct variant of moving average to get higher return than the buy and hold strategy and the reason to that seems to be that the price follows a random pattern which historical data rather useless for forecasting.

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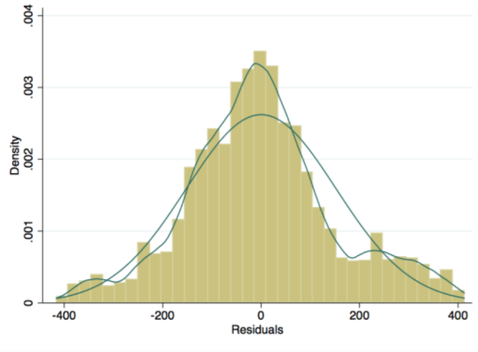
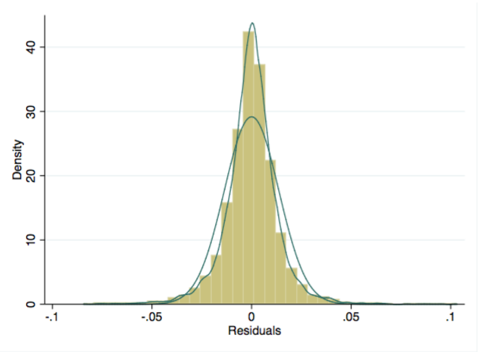
Appendix

Appendix 1

Residuals for the return from the different trading methods:

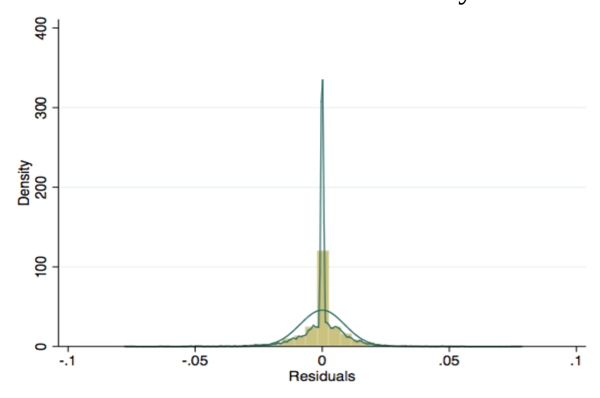


Closing price.

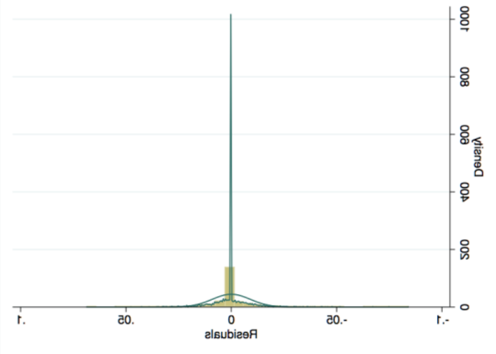


MA1-50

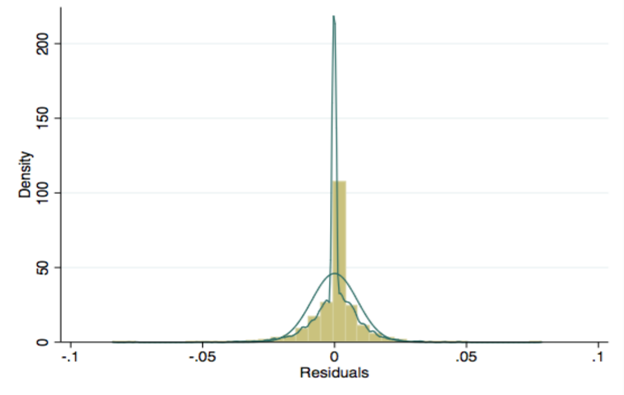
Residuals for the return from the buy and hold.



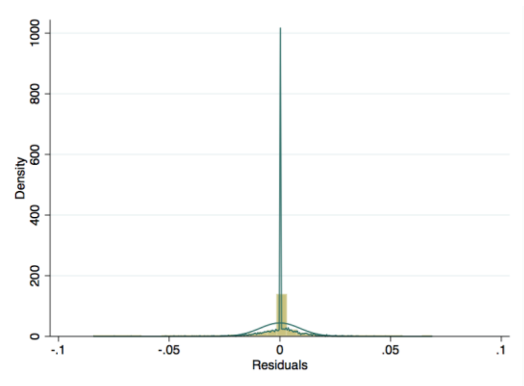
MA1-50 band



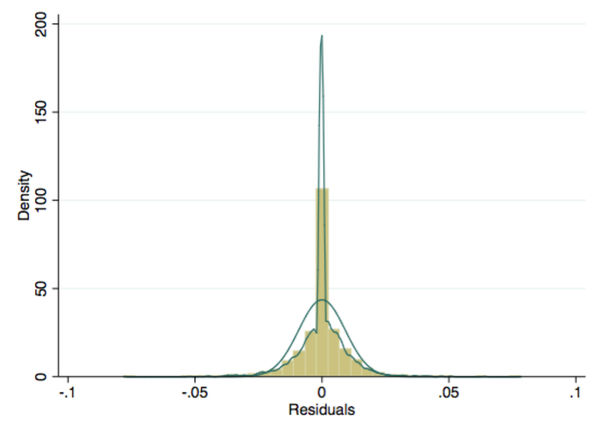
MA1-150

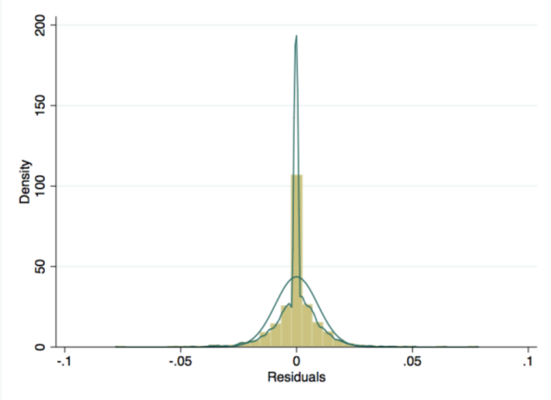


MA1-150 band



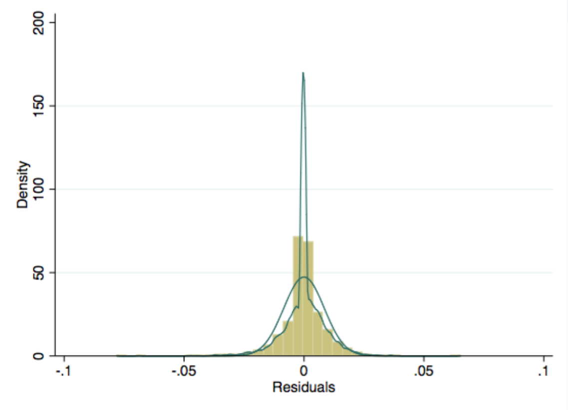
MA1-200

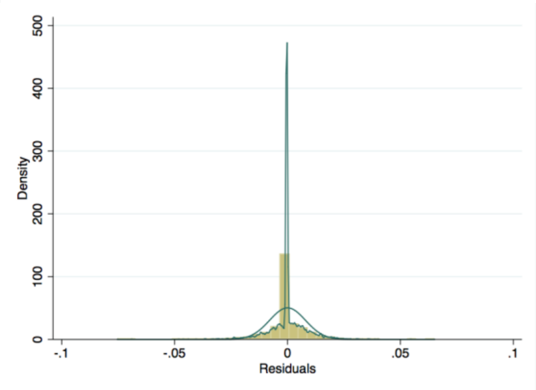




MA1-200 band

MA 5-150

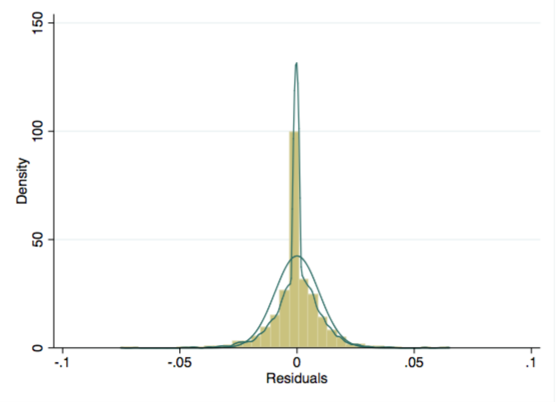




MA5-150 band

MA2-200

MA150-200



MA2-200 band

Appendix 2

MA1-50 **MA5-50**

		1-20 Band
t_{obs}	-2,149435824	-2,968724757
t_{crit}	±1,96057511	±1,96057511

	MA1-150	**MA1-150 Band**
t_{obs}	-0,935459353	-0,935459353
t_{crit}	±1,96057511	±1,96057511

	M1-200	**MA1-200 Band**
t_{obs}	-0,935459353	-0,935459353
t_{crit}	±1,96057511	±1,96057511

	MA5-150	**MA5-150 Band**
t_{obs}	-0,761462591	-0,020585527
t_{crit}	±1,96057511	±1,96057511

	MA2-200	**MA2-200 Band**
t_{obs}	-0,302667567	-1,800073449
t_{crit}	±1,96057511	±1,96057511

Appendix 3

BnH analysis		**MA1-50 Analysis**	**MA1-150 Analysis**
Mean		**No band**	**No band**
	1,000392337	*Mean*	*Mean*
Std.dev		1,000157432	1,000266604
	0,013648875	*Std.dev*	*Std.dev*
Varians		0,008472214	0,008268008
	0,000186292	*Varians*	*Varians*
Return		7,17784E-05	6,836E-05
	3,197356448	*Return*	*Return*
Number of buy signals		1,602391475	2,465400923
No buy or sell		*Number of buy*	*Number of buy*
Subperiod 1 03-07		2538	2659
Mean		*Number of sell*	*Number of sell*
	1,000811651	1347	1226
Std.dev		**Subperiod 1 03-07**	**Subperiod 1 03-07**
	0,010547398	*Mean*	*Mean*
Varians		1,000490959	1,000536295
	0,000111248	*Std.dev*	*Std.dev*

Return	0,007476961	0,007984948
2,326175994	*Varians*	*Varians*
Number of buy signals	5,5905E-05	6,37594E-05
No buy or sell	*Return*	*Return*
Subperiod 2 07-13	1,677027153	1,75631984
Mean	*Number of buy*	*Number of buy*
1,000144476	822	871
Std.dev	*Number of sell*	*Number of sell*
0,017591412	295	246
Varians	**Subperiod 1 07-13**	**Subperiod 1 07-13**
0,000309458	*Mean*	*Mean*
Return	1,000029817	1,000097972
0,984912009	*Std.dev*	*Std.dev*
Number of buy signals	0,010239628	0,009516497
No buy or sell	*Varians*	*Varians*
Subperiod 3 13-18	0,00010485	9,05637E-05
Mean	*Return*	*Return*
1,000318363	0,965936163	1,082700002
Std.dev	*Number of buy*	*Number of buy*
0,010191681	869	880
Varians	*Number of sell*	*Number of sell*
0,00010387	647	636
Return	**Subeperiod 13-18**	**Subeperiod 13-18**
1,395568162	*Mean*	*Mean*
Number of buy signals	1,000014391	1,000230184
no buy or sell	*Std.dev*	*Std.dev*
	0,006764296	0,006743743
	Varians	*Varians*
	4,57557E-05	4,54781E-05
	Return	*Return*
	0,989190884	1,296509817
	Number of buy	*Number of buy*
	847	908
	Number of sell	*Number of sell*
	405	344
	With band	**With band**
	Mean	*Mean*
	1,000148157	1,000294296
	Std.dev	*Std.dev*
	0,008237751	0,008273712
	Varians	*Varians*
	6,78605E-05	6,84543E-05
	Return	*Return*

1,557992889	2,744852286
Number of buy	*Number of buy*
2508	2653
Number of sell	*Number of sell*
1377	1232
Subperiod 1 03-07	**Subperiod 1 03-07**
Mean	*Mean*
1,000413504	1,000654354
Std.dev	*Std.dev*
0,007406303	0,007917996
Varians	*Varians*
5,48533E-05	6,26947E-05
Return	*Return*
1,538993213	2,004959944
Number of buy	*Number of buy*
809	867
Number of sell	*Number of sell*
308	250
Subperiod 1 07-13	**Subperiod 1 07-13**
Mean	*Mean*
1,000047279	1,000081495
Std.dev	*Std.dev*
0,009956548	0,009549767
Varians	*Varians*
9,91328E-05	9,11981E-05
Return	*Return*
0,996265252	1,055478981
Number of buy	*Number of buy*
891	882
Number of sell	*Number of sell*
625	634
Subeperiod 13-18	**Subeperiod 13-18**
Mean	*Mean*
1,000033571	1,000230733
Std.dev	*Std.dev*
0,006442862	0,00677339
Varians	*Varians*
4,15105E-05	4,58788E-05
Return	*Return*
1,016140552	1,297070818
Number of buy	*Number of buy*
841	896
Number of sell	*Number of sell*

		411	356

MA1-200 Analysis	MA5-150 Analysis	MA2-200 Analysis
No band	No band	No band
Mean	*Mean*	*Mean*
1,000284687	1,000345472	1,000302445
Std.dev	*Std.dev*	*Std.dev*
0,008581778	0,008539836	0,00868369
Varians	*Varians*	*Varians*
7,36469E-05	7,29288E-05	7,54065E-05
Return	*Return*	*Return*
2,617653317	3,320509541	2,795450705
Number of buy	*Number of buy*	*Number of buy*
2777	2670	2771
Number of sell	*Number of sell*	*Number of sell*
995	1215	1114
Subperiod 1 03-07	**Subperiod 1 03-07**	**Subperiod 1 03-07**
Mean	*Mean*	*Mean*
1,000556466	1,000643896	1,00056586
Std.dev	*Std.dev*	*Std.dev*
0,008398877	0,008014002	0,008364574
Varians	*Varians*	*Varians*
7,05411E-05	6,42242E-05	6,99661E-05
Return	*Return*	*Return*
1,789450649	1,97999242	1,808901626
Number of buy	*Number of buy*	*Number of buy*
907	873	904
Number of sell	*Number of sell*	*Number of sell*
97	244	213
Subperiod 1 07-13	**Subperiod 1 07-13**	**Subperiod 1 07-13**
Mean	*Mean*	*Mean*
1,000096204	1,000262629	1,000192075
Std.dev	*Std.dev*	*Std.dev*
0,009741355	0,010059187	0,010006927
Varians	*Varians*	*Varians*
9,4894E-05	0,000101187	0,000100139
Return	*Return*	*Return*
1,076256996	1,378929687	1,239871625
Number of buy	*Number of buy*	*Number of buy*
919	894	919
Number of sell	*Number of sell*	*Number of sell*

597	622	597
Subeperiod 13-18	**Subeperiod 13-18**	**Subeperiod 13-18**
Mean	*Mean*	*Mean*
1,00027044	1,00017954	1,000201075
Std.dev	*Std.dev*	*Std.dev*
0,007112061	0,006808994	0,007087039
Varians	*Varians*	*Varians*
5,05814E-05	4,63624E-05	5,02261E-05
Return	*Return*	*Return*
1,359178246	1,216183434	1,246407829
Number of buy	*Number of buy*	*Number of buy*
951	903	948
Number of sell	*Number of sell*	*Number of sell*
301	349	304
With band	**With band**	**With band**
Mean	*Mean*	*Mean*
1,000315191	1,000354249	1,000315297
Std.dev	*Std.dev*	*Std.dev*
0,008710135	0,008651869	0,008721227
Varians	*Varians*	*Varians*
7,58665E-05	7,48548E-05	7,60598E-05
Return	*Return*	*Return*
2,934687524	3,422761715	2,93482085
Number of buy	*Number of buy*	*Number of buy*
2766	2684	2750
Number of sell	*Number of sell*	*Number of sell*
1119	1201	1135
Subperiod 1 03-07	**Subperiod 1 03-07**	**Subperiod 1 03-07**
Mean	*Mean*	*Mean*
1,000578049	1,000660561	1,000571416
Std.dev	*Std.dev*	*Std.dev*
0,00838173	0,008116915	0,00836667
Varians	*Varians*	*Varians*
7,02534E-05	6,58843E-05	7,00012E-05
Return	*Return*	*Return*
1,833391899	2,015259092	1,820123178
Number of buy	*Number of buy*	*Number of buy*
897	870	885
Number of sell	*Number of sell*	*Number of sell*
220	247	232
Subperiod 1 07-13	**Subperiod 1 07-13**	**Subperiod 1 07-13**
Mean	*Mean*	*Mean*
1,000177742	1,000244801	1,000191892

Std.dev	*Std.dev*	*Std.dev*
0,010015338	0,010130708	0,01004833
Varians	*Varians*	*Varians*
0,000100307	0,000102631	0,000100969
Return	*Return*	*Return*
1,213060993	1,340693724	1,23874854
Number of buy	*Number of buy*	*Number of buy*
923	894	923
Number of sell	*Number of sell*	*Number of sell*
593	622	593
Subeperiod 13-18	**Subeperiod 13-18**	**Subeperiod 13-18**
Mean	*Mean*	*Mean*
1,000247108	1,000213493	1,000236221
Std.dev	*Std.dev*	*Std.dev*
0,007154788	0,007007612	0,007156843
Varians	*Varians*	*Varians*
5,1191E-05	4,91066E-05	5,12204E-05
Return	*Return*	*Return*
1,319544133	1,26682376	1,301660303
Number of buy	*Number of buy*	*Number of buy*
957	925	955
Number of sell	*Number of sell*	*Number of sell*
295	327	297

Appendix 4

Following commands in STATA where used for the moving average tests

```
/*Creating residuals for each trading strategy and conducting a test
for normal distribution*/
reg rbnh Tid, robust
predict crbnh, resid
reg rma520 Tid, robust
predict crma520, resid
reg rma250 Tid, robust
predict crma250, resid
reg rma2050 Tid, robust
predict crma2050, resid
reg rma2150 Tid, robust
predict crma2150, resid
reg rma150200 Tid, robust
predict crma150200, resid
reg brma520 Tid, robust
predict cbrma520, resid
reg brma250 Tid, robust
```

```
predict cbrma250, resid
reg brma2050 Tid, robust
predict cbrma2050, resid
reg brma2150 Tid, robust
predict cbrma2150, resid
reg brma150200 Tid, robust
predict cbrma150200, resid
ssc install jb
jb crbnh
histogram crbnh, kdensity normal
histogram crma520, kdensity normal
histogram crma2050, kdensity normal
histogram crma250, kdensity normal
histogram crma2150, kdensity normal
histogram crma150200, kdensity normal
histogram cbrma520, kdensity normal
histogram cbrma520, kdensity normal
histogram cbrma250, kdensity normal
histogram cbrma2050, kdensity normal
histogram cbrma2150, kdensity normal
histogram cbrma150200, kdensity normal
histogram Close, kdensity normal
```

Following commands in STATA where used for the Efficient Market Hypothesis tests

```
/*Importing data that contains Date and Closeprice with purpose to
investigate the Efficient Market Hypothesis*/
import excel "C:\Users\gusfridehj\Downloads\Stata4.xlsx", sheet("Blad1") firstrow
drop if Closeprice == .
tsset Date
tsfill
*Starting to modify the data set to fit our purpose
gen lncp=ln(Closeprice)
line lncp Date
label var lncp "lnCloseprice"
twoway (tsline lncp)
reg Closeprice Date
predict resCp, resid
reg lncp Date
predict reslncp, resid
reg reslncp l.reslncp
browse
reg Closeprice Date
estat bgodfrey, lag(1)
reg Closeprice Date
dwstat
/*We have significant autocorrelation and the ts looks like a RWM with
drift, dwstat close to zero indicate rho close to one*/
*Deeper test of random walk
*First, test of RW without drift
```

```
reg lncp l.lncp
histogram reslncp, kdensity normal
ssc install jb
jb reslncp
/*Regression lncp on lagged on lagged lncp gives almost rho=1.
This indicates that we have somthing that looks like a unit root.
Testing different model specification to test which king of
model we have, deterministic, rwm with rift or without drift*/
reg lncp Date l.lncp
*B0 B1 and B2 is significant, Date has a weaker significans
*Sample correlogram with following Q-statistic test
corrgram lncp
wntestq lncp
/*Shows high Qstat which is test for chi-square distribution.
It also show a high rho value that slowly goes towards zero*/
gen difflncp = d.lncp
reg difflncp l.lncp
/*Dickey Fuller homemade test, follow tau distribution, test if H0
is zero, if it is then we can not reject the hypothesis that rho=1.
We can not tejct H0 so the one sided test also indicates
nonstationarity, B0 also insig.*/
*Flolowing tests are unit root test
reg difflncp l.lncp Date
estat bgodfrey, lag(1)
*The test show taht we have autocorrelation among error terms.
*Since that result, Philips-Perron are chosed insted of Dickey-Fuller
/*Trend, drift and noconstant tell STATA to test the different types of
random walk*/
pperron lncp, trend
pperron lncp, drift
pperron lncp, noconstant
*Every test implies that it is a random walk with drift we have

**************************The end of do-file**************************
```

Appendix 5

Creating different moving averages, the number vary due to which kind of moving average that is created, this is for the MA2-150. All the examples is for cell number two:

```
=AVERAGEA(E2:E151)
```

Return for buy and hold:

```
=SUMMA(E2/E3)
```

Creating trading signals:

```
=OM(OCH(N2>K2;N3<K3);1;OM(OCH(N2<K2;N3>K3);-1;0))
```

Creating trading signals with band:

First the ratio between the short and the long moving average

```
=L2/G2
=OM(OCH(BA2<0,99;BA3>0,99);-1;OM(OCH(BA2>1,01;BA3<1,01);1;0))
```

Creating holding signals:

```
=OM(P3=0;Q3;P3)
```

Return from tradig strategy:

=OM(Q2=1;H2*1;1)
Caluculate average, std.div and variance:
=AVERAGEA(H2:H3886)
=STDAV.P(H2:H3886)
=VARIANS.P(H2:H3886)
Calculate total return from MA strategy (this is the geometric return):
=PRODUKT(BT2:BT3886)
Calculate the total return for Buy and hold:
=PRODUKT(H2:H3886)

Appendix 6

LAG	AC	PAC	Q	Prob>Q	[Autocorrelation]	[Partial Autocor]
1	0.9981	0.9986	3780.2	0.0000		
2	0.9962	0.0582	7547.7	0.0000		
3	0.9945	0.0502	11303	0.0000		
4	0.9928	0.0325	15047	0.0000		
5	0.9911	0.0135	18778	0.0000		
6	0.9895	0.0601	22498	0.0000		
7	0.9879	-0.0055	26208	0.0000		
8	0.9863	0.0331	29906	0.0000		
9	0.9848	0.0026	33595	0.0000		
10	0.9832	-0.0044	37272	0.0000		
11	0.9817	0.0389	40940	0.0000		
12	0.9802	-0.0131	44596	0.0000		
13	0.9786	-0.0229	48242	0.0000		
14	0.9770	0.0093	51877	0.0000		
15	0.9754	0.0265	55501	0.0000		
16	0.9738	0.0013	59113	0.0000		
17	0.9721	-0.0141	62715	0.0000		
18	0.9704	-0.0401	66305	0.0000		
19	0.9685	0.0028	69882	0.0000		
20	0.9668	0.0446	73447	0.0000		
21	0.9651	0.0019	77000	0.0000		
22	0.9634	-0.0315	80542	0.0000		
23	0.9616	0.0103	84072	0.0000		
24	0.9599	0.0015	87590	0.0000		
25	0.9581	-0.0091	91095	0.0000		
26	0.9562	-0.0376	94589	0.0000		
27	0.9543	-0.0264	98069	0.0000		
28	0.9524	-0.0098	1.0e+05	0.0000		
29	0.9505	0.0170	1.0e+05	0.0000		
30	0.9486	-0.0097	1.1e+05	0.0000		