Copenhagen Business School
HANDELSHØJSKOLEN

MSc in Finance and Strategic Management

Department of Finance

Momentum Investment Strategy

An empirical and explorative study on price momentum

– The Danish evidence

Master's Thesis at the FSM line

Copenhagen, 26 September 2008

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Copenhagen Business School, 2008

Executive summary

Price momentum is the continuation of stock price movements and price momentum strategies tries to exploit these price movements in order to make a profit. This Master thesis investigates the characteristics of price momentum, the possible causes of price momentum as well as the possible occurrence of price momentum in the Danish stock market through the application of a price momentum strategy.

The traditional finance theories and behavioral finance theories are based on different assumptions about investor behaviour and the resulting aggregate market. A trading strategy that buys stocks that have performed well in the past and sell stocks that have performed poorly in the past would be profitable if price momentum exists. The Efficient Market Hypothesis and related traditional finance theories are built on assumptions that would make any price momentum strategy unprofitable. Behavioral finance theories, that contradict traditional finance theories, incorporate the psychology of the investor and other more socially founded factors in order to explain "non-efficient" price movements in the capital markets.

An empirical study documenting the profitability of price momentum strategies on the Danish stock market in the period 1988-2008 was conducted. 79 Danish stocks listed on the Copenhagen Stock Exchange in this period were included in the data sample. The stocks were ranked on a monthly basis according to their past 6-month returns and divided into portfolios. A long-short zero-cost trading strategy, which each month took a long position in the portfolio with the highest past 6-month return and a short position in the portfolio with lowest past 6-month return was applied during the entire 20-year period. The empirical study showed that this strategy yielded a monthly return of 1.26 percent as opposed to the 1.11 percent that an Equal Weighted Index yielded representing the average of all the portfolios. A strategy that would have taken a long position in the portfolio with the highest past 6-month return would have yielded 1.96 percent. The results still hold after adjusting for risk.

The study shows that momentum is prevalent in the Danish stock market. The behavioral finance theories citing different psychological factors as causes of the existence of price momentum are plausible and more than qualified alternative market theories to the existing traditional finance theories. Price momentum is no longer a market anomaly but a dominating market factor.

Contents

1 Introduction

Buy past winners and sell past losers. This is one of most simple trading strategies an investor on the stock market can choose to apply. It seems almost counterintuitive that such a simple strategy would be profitable in global stock markets, where professional market participants such as portfolio managers, fund managers and stock dealers every day trade stocks in huge volumes. None the less strategies that follow this simple investment rule has been the subject of many empirical studies. An investment strategy that buys past winners and sells past losers is also called a momentum strategy, because it is constructed as it is so it can exploit the on-going price movements of stocks. The intuition behind the strategy is very simple as it logically concludes that stocks that have done well in the past will also do well in the future. But if past stock prices are any indication of how stocks will perform in the future, this violates the very core assumptions of the traditional finance theories that are being taught at business schools around the world.

But the existence of price momentum has been empirically proven to exist on many markets, and the mere existence of such a market anomaly has indicated that alternatives to the traditional finance theories are in great demand. The Efficient Market Hypothesis and the Capital Asset Pricing Model fail to capture the overtly unpredictable momentum behaviour of stock prices. Proponents of classical finance theories argue that these anomalies are nothing more than rare deviations from the efficient market, yet momentum has been proven to exist over several decades. If price momentum do exist this would imply some sort of irrational (or at least irrational from the perspective of traditional finance theories) investment behaviour, which is why the documented existence of price momentum has been a strong argument for the development of behavioral finance theories, that can describe and analyze these anomalies. Behavioral finance is a broad set of theories that use the psychological and social behaviour of investors to explain why markets deviate from the efficient market and has become an increasingly popular field of research within the last couple of decades.

But although the many empirical findings support the existence of price momentum, there is still doubt about the profitability of momentum strategies as transaction costs, market limitations, opportunity costs and high risk would render the strategies unprofitable and impossible to implement as a trading strategy. Still price momentum remains one of the unsolved puzzles in the world of finance. This phenomenon, although relatively new, has been investigated thoroughly throughout the years, but the cause of momentum is still being debated, as the only robust finding of the empirical studies seems to be the mere existence of price momentum.

Momentum or the continuation of stock returns on the intermediate horizon (3-12 months), as an empirical fact and a price anomaly puzzle was first discovered and thoroughly proved by Jegadeesh and Titman (1993), although prior research studies had indicated the existence of price momentum[1]. Since then the financial phenomenon of price momentum has continued to confuse and divide financial researchers, academics and practitioners. Momentum and the larger theoretical context of behavioral finance appear to be one of the most confusing academic subject areas in economics. One of the reasons to the perplexity of this research field is that both financial academics and trading practitioners contributes to the literature on price momentum, and their way of approaching the subject is very different. For the practitioners the academic debate about the causes of price momentum can seem redundant, but nonetheless finance academics produce a lot of theoretical theses and behavioral models that suggest possible causes to this pricing anomaly. But most of the theory developed on the causes to price momentum is contradicting and no consensus has been reached as to why price momentum exists. Some studies point to stock-specific factors, other studies use industry to explain momentum and again other studies use the argument of broader macroeconomic conditions as their explanation. Some studies also argue that price momentum is an insignificant anomaly that never will persevere, and that the temporary deviation from the efficient market can be explained by risk factors, an argument, which strongly supports the traditional finance literature.

Due to the observed discrepancies listed above that surround price momentum on stock markets and the lack of academic investigation and study of price momentum on the Danish stock market, I have chosen to examine the price momentum phenomenon from a Danish perspective.

[1] Cootner (1964) examined the existence of price momentum through statistical analysis, but his database was inadequate.

1.1 Thesis Statement

The overall intent and purpose of this Master thesis will be to:

- Examine the characteristics and possible existence of price momentum.

In order to fulfil the purpose of the thesis statement several aspects of the price momentum issue will have to be analyzed. The thesis will analyze price momentum from an empirical as well as a theoretical perspective. The purpose of the following research questions is to enlighten the necessary aspects of price momentum, and by answering the research questions sufficient data and analytical material will be produced so that a qualified thesis can fulfil the purpose of the thesis statement. The research questions are listed below in a non-prioritized order:

<u>Theoretical research questions:</u>

- What are the contradictions in assumptions that traditional finance theories and behavioral finance theories are based upon?
- What is the resulting aggregate market effect of certain investor behaviour?
- How do momentum strategies work in theory and what have been the hypothesized causes to their high performance?

<u>Empirical research questions:</u>

- Based on historical stock data from the Danish stock market, would a momentum strategy that buy past winners and sell past losers have been profitable?
- Does the observed Danish stock returns confirm or reject the traditional finance theories?
- If price momentum characteristics are prevalent and identifiable in the Danish stock market data, which properties are inherent in momentum?
- What are the similarities and differences between the empirical results of this study and prior empirical research made on momentum strategies?

The information required to answer these research questions will be studied and analyzed in different sections of the thesis, so a qualified answer to these questions can be formulated.

1.2 Methodology

This section will give a brief overview of the methodology applied in the thesis. In the different theoretical and empirical sections, the choice of methodology, theories and studies will be elaborated on. As a consequence of this the precise methodology of the data and the empirical analysis in the empirical study will not be described here, but will be described in the section concerning the empirical study, as this seems most appropriate.

The subject of the matter will to a great extend dictate the methodology of the master thesis. In the theoretical section the methodology will be deductive as the relevant parts of the various theories are used to enlighten the aspects important for the aim of this thesis. Contrary the methodology will be inductive in the empirical study, as the empirical observations and results are used to make a broader generalization that will encompass the purpose of the study.

An extensive research section dedicated to the competing theoretical fields of traditional finance and behavioral finance helps understand the theoretical framework that momentum is a part of and the theoretical framework in which momentum is seen as a temporary deviation. The research section also shows the linkages between the two fields of research and helps create an overview of the extensive literature in both fields. The research consisted in reading primary and secondary literature within traditional finance, economics and behavioral finance. Most of the literature is scientific articles that have been published in financial or economic journals. All the sources have been screened and have been published in credible journals.

As the thesis contains an empirical study but also describes the finding of similar empirical studies that have been conducted the methodology of the empirical study will be aligned with the methodology of Jeegadesh and Titman (1993), which is the most widely applied methodology in the momentum field of research. Therefore Jeegadesh and Titman (1993) will be chosen as a benchmark study in order to ensure a high degree of comparability with the empirical study made on the Danish stock market.

1.3 Limitations

In this section the specific methods and empirical investigations procedures, which will not be applied in this study due to the scope of the thesis are mentioned. Albeit the following methods are reasonable they are seen as less important in fulfilling the purpose and objective of this assignment.

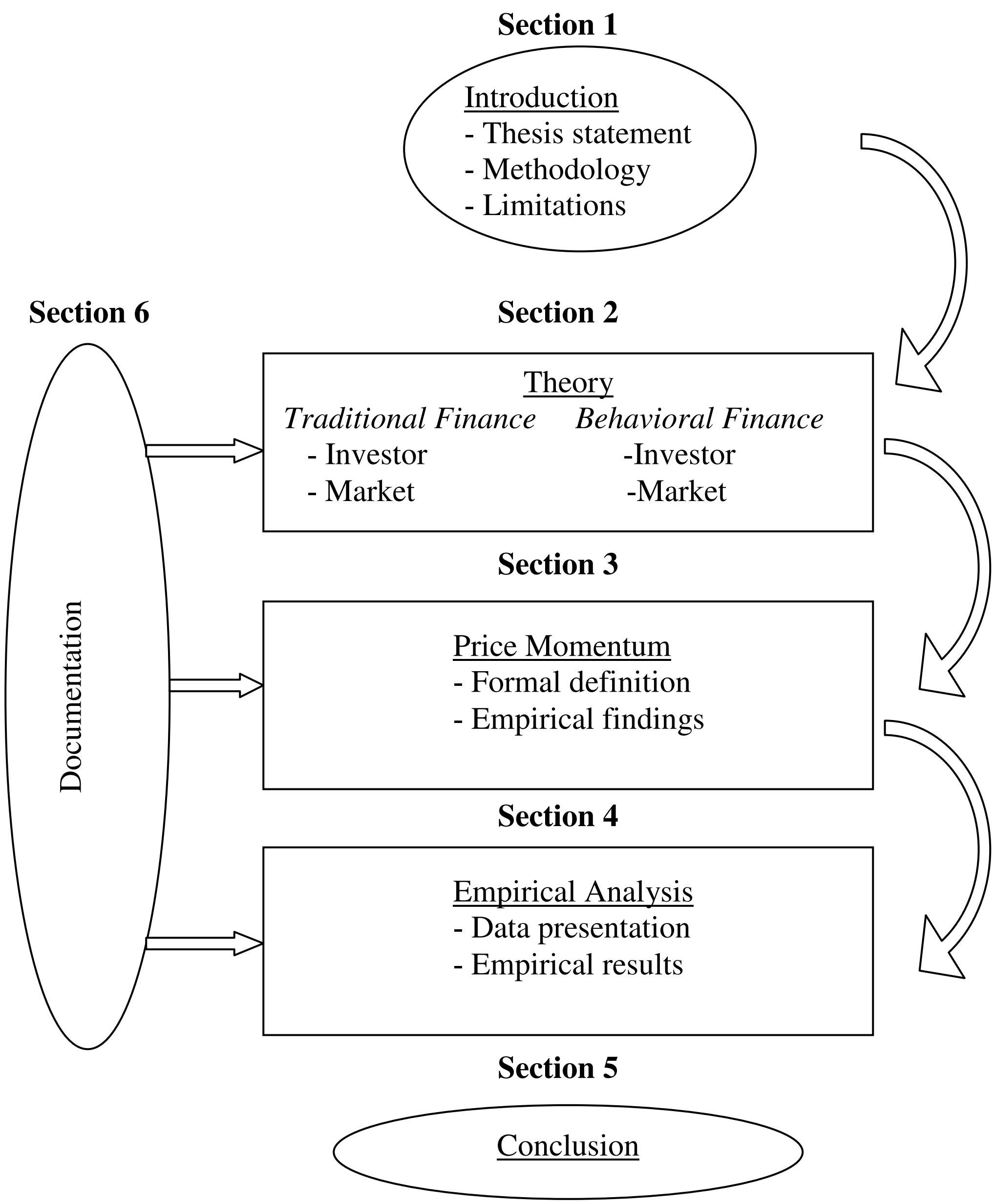
Part of the thesis will be dedicated to the description and discussion of the historical performance of momentum strategies. This will mainly be a discussion of the returns the momentum strategies have been empirically proven to generate. But the studies are academic in nature and whether or not the strategies would have proven to be profitable in a given market involves additional considerations, such as the degree of turnover and trading costs (especially selling short entails high trading costs) necessitated by the strategies. These considerations are however beyond the scope of this thesis. Furthermore is not possible to describe most of the studies made on momentum, although the research area is still relatively new an extensive body of work exists and therefore only the most relevant academic contributions will be discussed.

The sample of stocks applied in the empirical study of the Danish stock market will not be as large and exhaustive as most of the studies in this field of research. This is due to the limited size and small cap nature of the Danish stock market. The sample size could have been more inclusive but that would have meant the inclusion of very small and illiquid stocks. It is imperative that small and illiquid stocks are excluded from the stock sample for two reasons. Firstly, in order for the results not to be driven by illiquid stocks which are costly and difficult to trade, and secondly to make the results to be comparable to other studies, which also for the most part exclude small and illiquid stocks from their sample. The empirical study will also not be complicated and thorough as other momentum studies. The portfolio formation method and return calculation will however not be affected by this, but the various methods used in previous research to detect the source of momentum profits will not be applied. These methods refer to various ways of dividing the basis sample into sub samples in order to identify if market cap, book-to-market and beta measures have a significant influence on the profitability of momentum strategies. I will also not use the Fama-French three-factor model, which would otherwise make me able to contribute the source of returns to various factors. A study on that level requires more time and resources than what is available for a Master thesis.

1.4 Structure

Figure 1.1 graphically illustrates the structure of the study. The master thesis consists of 6 sections. In section 1 the subject of the study is specified as well as the scope and aim of the master thesis. The thesis statement and research questions are formulated. Sections 2-4 are the core sections of the study that is the foundation from which the thesis statement can be answered and section 5 concludes on the findings of the study. Section 6 is the documentation in form of source references that has been applied through sections 2-4.

Figure 1.1 Structure of the study



In section 1 the subject of the study is presented and described and the thesis statement is formulated. After the thesis statement follows the research questions, which are imperative to answer in order to be able to give a qualified response to the thesis statement. The section also contains methodology and limitation specifications.

Section 2 describes various theoretical models within two competing fields of research: traditional finance and behavioral finance. An overview of the most important theories in the field of traditional finance is contrasted with an overview of the most important behavioral finance theories in order to understand the different assumptions that the two theoretical fields are based upon. This structure helps understand the momentum phenomenon as it is put into the larger theoretical context from which it arises (behavioral finance) as well as contrasted with the theoretical field that it contradicts (traditional finance framework). Both fields of research are further divided into two separate subsections. The first subsection contains theories that describe individual investor behaviour and the second subsection then contains theories that describe aggregate market behaviour given that individual investors exhibit certain behaviour. The theories developed on individual investor behaviour are helpful because it helps identify characteristic investor traits that could create an aggregate investor sentiment on a given market. The identification of such investor sentiments will help understand the hypothesized nature of momentum.

In section 3 momentum as a price phenomenon and behavioral investment strategy is described in detail. Firstly the concept of momentum is defined and described. Then it is explained how the momentum phenomenon can be exploited in behavioral investment strategies. Finally the section gives a detailed description of the empirical research conducted on momentum investment strategies. In this part of the section the empirical results that document the existence of price momentum on various markets using various data samples will be presented.

Section 4 is dedicated to the empirical momentum study, which is conducted on the Danish stock market. Firstly the data sample and methodology will be presented and then the empirical results will be presented and commented on. The empirical study will be based on time-series data of 79 representative Danish stocks. The individual monthly stock prices dating back almost 20 years will be analyzed in order to investigate the possible occurrence of price momentum characteristics on the stock market in Denmark.

Section 5 concludes the study. In this section the answers to the research questions obtained in sections 2-4 are linked to the thesis statement and the findings are summarized.

Section 6 contains the bibliography with the various academic sources used in sections 2-4 in order to make the thesis robust.

2. Theory

In this section we will look at finance theories that delve into investor and market behaviour. The theory section is divided into two main parts, where the first part describes the traditional finance and economic theories that are the most common and widespread theories and the second part which describes behavioral finance theories, which deviate from the original finance and economic theories through its main assumptions about investor behaviour. As aggregate market behaviour can bee seen as a result of the sum of the parts, and therefore as a result of individual investor behaviour, the two main parts are both subdivided into two parts as well. The first part describes the main theories of investor rationality, behaviour etc. and the second part describes the resulting aggregate market theories. This division helps to understand how the traditional finance and economic framework and the behavioral finance framework are built on different assumptions about the investor and also underline the theoretical importance of investor behaviour. The inclusion of traditional finance theory is also importance in the context of price momentum because the understanding of why and how price momentum strategies can prove to be profitable necessitates the understanding of which theories price momentum is supported by, but more importantly which theories it rejects.

2.1 Traditional finance and economics theory

2.1.1 The investor

Rational Choice Theory

Rational Choice Theory (RCT) is an essential part of the traditional economic framework as it describes the processes that underlie the choices made by investors or economic agents. RCT explains human behaviour by assuming that participants in a market maximize their expected utility from a static, well-defined set of preferences and accumulate an optimal amount of information and other useful inputs for decision-making from the markets in which they operate (Jolls et al., 1998). Agents are assumed to be perfectly rational and motivated by self-interest. This implies that every time an agent faces a personal trade-off, e.g. between different investment portfolios with different risk and expected return profiles, RCT assumes that he or she assigns a utility score (or welfare score) to each competing investment portfolio based on the expected return and risk of the investment portfolios and based on the degree of risk aversion of the agent. The agent would then rationally select the portfolio that provides the highest utility score (Bodie et al., 1999). Furthermore every agent in a market is assumed to have access to the same pool of information.

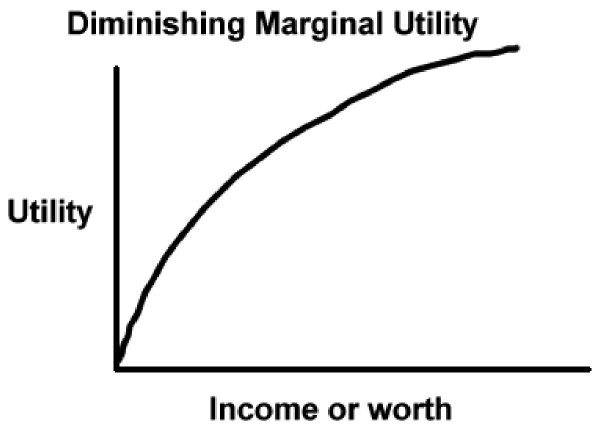
RCT focuses on actions taken in competitive circumstances. The underlying assumption is that competition forces the agents to become more effective by behaving according to rational principles or they will not survive in the market. It is accepted that economic agents are subject to errors in decision-making but the errors are assumed to be of a random rather than a systematic nature since agents who make systematic errors would be exploited other agents and forced to withdraw from the market (Hogarth and Reder, 1987).

Expected Utility Theory

Expected Utility Theory (EUT) assumes that investors are always risk averse and that utility is a function of total wealth. Investors make choices to maximize expected utility, where utility is a function of total wealth. The utility function for investors is concave. That implies that they will always prefer a sure amount of wealth to an unsure amount of wealth but with the same expected value. For instance if an investor was offered to take part in a game where there was a 50 percent chance of winning $1,000 and a 50 percent change of receiving no money, the investor would prefer a sure gain of $500 (or even less depending on the degree of risk aversion) instead of playing the game although the game has an expected value of $500 as well. That is because the expected utility of the game is less than the expected utility of the sure amount, according to the standard utility function. Similarly the investor would prefer a sure loss of $500 to a 50 percent change of a sure $1,000 loss (Fisher et al., 1999). This is because the investor is risk averse, had the investor been risk neutral he or she would have been indifferent if the same choice had to be made.

Besides the assumption that investors are always risk averse, there is also an assumption in EUT that utility is a function of total wealth. This entails that any increase in wealth will automatically result in an increase in utility. It also implies decreasing marginal utility. The concavity of the standard utility function tells us that with each additional dollar invested, the resulting additional utility becomes less and less. Therefore an investor who only had $500 would assign a greater utility value to an extra dollar earned than an investor who had a net worth of $200,000 (Bodie et al., 1999). This is illustrated in the *figure 2.1* below:

Figure 2.1 Utility curve



2.1.2 The market

Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) has been the cornerstone of modern finance theory for many years. EMF defines an efficient financial market as one in which security prices always fully reflect the available information. Securities are always priced correctly given the available information and when new information arrive this is immediately incorporated into the given security price. This entails that it is not possible for an investment strategy, which is based solely on information to achieve an abnormal return and beat the market. Therefore in a market where the EMH is valid, the best investment strategy is to passively buy and hold the market portfolio (Shleifer, 2000). Markets arise naturally and operate efficiently and investors are assumed to be fully rational, and to trade basis of all the available information. Imperfections in the market occur, but are quickly removed by arbitrage, in which traders spot anomalies in pricing and earn a profit by exploiting these anomalies. Consequently the exploitation helps remove the pricing anomaly. Therefore the price of a security will always equal its "fundamental value" or otherwise it will quickly reverse back to this "fundamental value". The "fundamental value" is then the discounted sum of expected future cash flows, where investors correctly derive the expectations about future cash flows by processing all available information, and then applying a discount rate that incorporates the investors' preferences.

The EMH distinguishes between three forms of market efficiency (Fama, 1970):

- weak
- semi-strong
- strong.

The three forms of market efficiency assume three different ways that information is reflected in security prices.

In the weak market form security prices reflect the information that past security prices convey. In the weak market form it is impossible to consistently earn abnormal profits by studying past security returns, as past price movements cannot predict future price movements. It rules out trends cycles or any other predictable pattern of price movements, and therefore there is no scope for profitable technical trading strategies, since such strategies are based on information that is already reflected in market prices. In the weak market form prices follow a random walk pattern.

If a market is in a state of semi-strong market form, security prices reflect all publicly available information regarding the prospects of the company (press releases, annual reports, earnings announcements, stock issues, mergers and acquisitions etc.) in addition to the information of past security prices. When markets are semi-strong efficient prices will adjust immediately when new public information about a given company emerges. Investors cannot predict future price movements simply by analyzing macroeconomic or firm-specific news as the market has already correctly priced this information. This excludes systematic overreaction or underreaction.

Finally the strong form of efficiency states that security prices reflect all information relevant to the company, even information only available to company insiders. This entails that no investor can ever profit from information, not even inside information, as this information has already been priced. In such a strong market there can be lucky and unlucky investors, but no investor that consistently beat the market (Brealey & Myers, 2003)

Capital Asset Pricing Model and the Arbitrage Pricing Theory

The Capital Asset Pricing Model (CAPM) is an economic model that solves the problem of determining the market price of risk and of measuring risk of a single asset, and it is also referred to as an equilibrium asset-pricing model. CAPM was derived from the work of Markowitz (1959), in where the term mean-variance efficient portfolio was coined. The term describes how investors seek to minimize the variance on the return of the portfolio given the expected return and how investors seek to maximize the expected return given the variance of the portfolio. The CAPM makes mathematical condition concerning the weight put on assets in mean-variance efficient portfolios. CAPM uses this mathematical restriction to make a testable prediction about the relation between risk and return, by identifying a portfolio, which has to be efficient if the price of the assets has to imply that you empty the market of all assets. Sharpe (1964) and Lintner (1965) further developed the CAPM and showed how investors have homogenous expectations about the future return of assets and hold the mean-variance efficient portfolio the market portfolio will also be a mean-variance efficient portfolio, given that no market restrictions exists. The CAPM also implies that the equilibrium return of all risky assets is a function of their covariance with the market portfolio. These finding can help price assets.

The CAPM is based on a number of assumptions about investors and the opportunity set (Grinblatt & Titman, 2002).

1) Investors are risk-averse individuals who maximize the expected utility of their end-of-period wealth.

2) Investors are price takers (Their buying or selling transactions have no effect on the market.), have homogenous expectations about asset returns and information is simultaneously distributed to all investors at no cost. Asset returns are assumed to follow a joint normal distribution (the joint normal distribution is a generalization of the normal distribution).

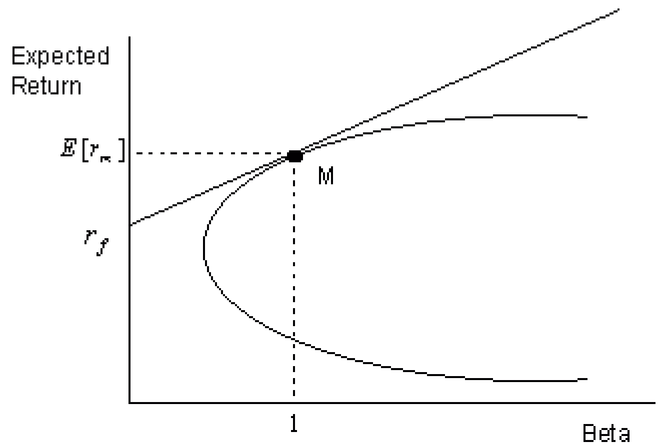
3) A risk-free asset exists and investors can borrow or lend unlimited amounts of money at the risk-free rate.

4) All assets are marketable and can be divided in to smaller assets.

5) No market imperfections exist such as taxes, regulation or restrictions on short selling. Also the market is frictionless, which implies that all investment transactions can by traded at any given time and in any given quantity, long positions as well as short selling. No transaction costs exist.

The implications of the assumption mentioned above are that investors prefer more return to less return and dislike more risk to less risk. All investors have the same preferences and their decisions are based on an identical opportunity set, which implies that all investors arrive at the same conclusions concerning mean returns and standard deviations on any given portfolio of assets. This also implies that it is impossible to outperform the market because no investor can create a portfolio that outperforms the market portfolio and thereby achieve greater returns than the market. The last assumption regarding the exclusion of market imperfections is unrealistic but none the less it is assumed to hold due to the concern for the simplicity of the CAPM. In *figure 2.2* we see a graphic presentation of the CAPM.

Figure 2.2 The Capital Asset Pricing Model



Source: www.progressdaily.com, 2008

On the horizontal axis the risk of the portfolios is denominated by the measure of beta, and on the vertical axis the expected return is denominated. The market portfolio has a beta of 1 because beta is a measure that indicates the correlation coefficient with the market. This entails that all portfolio on the right hand side of the market portfolio has a beta greater than 1, so that whenever the market return increases by 1 percent the portfolio return would increase with more than 1 percent. Along the curved line all the different portfolios with different risk and return profiles are represented. Along this line the variance on the return is minimized given the different levels of beta (this curve does not include risk-free assets). Because an investor will always choose the portfolio that is mean-variance efficient it entails that he or she would never choose a portfolio in the bottom half of the curve, because he or she could obtain a higher expected return for the same risk in the top half of the curve. Therefore only portfolios in the top half of the curve are said to be mean-variance efficient because it maximizes the return-to-risk reward. The straight line represents the inclusion of risk-free assets in the market. The straight line intersects the y-axis at the risk-free rate and also in M, which represents the market portfolio and this line is also called the Capital Market Line.

In addition to determining the risk and return profile of an asset, the CAPM is also very suitable for evaluating the performance of a portfolio or an investment strategy. The Sharpe ratio uses the Capital Market Line to measure the return-to-risk ratio of a portfolio or investment strategy and is defined as:

$$S_i = \frac{R_i - R_f}{\sigma_i}$$

In the above equation R_i denominates the return of a given portfolio, R_f denominates the risk-free rate of return, σ_i denominates the standard deviation of the portfolio and S_i is the resulting Sharpe ratio. The Sharpe ratio measures the slope of the Capital Market Line, and can be used to evaluate two or more competing portfolios. The one with the highest Sharpe ratio is the portfolio, which has performed the best. The Sharpe ratio will therefore be applied in the empirical study in this thesis, when the different momentum portfolios are evaluated.

The CAPM has been a popular asset-pricing model for a long time due to its simplicity, and the intuition behind it. The theory behind the CAPM gives a strong and satisfactory explanation of how the properties of the linkage between risk and return forecast work and how risk and return can be measured. The CAPM is still widely used for estimating the capital cost of a company or for evaluating the performance of managed portfolios, but many empirical tests have shown that the CAPM does correctly forecast and capture the linkage between risk and return. When empirically testing for momentum a given market, you are actually at the same time testing if the CAPM model holds.

If a given momentum strategy proves to be profitable and an actual momentum hypothesis is adopted it rejects the CAPM at the same time. This is because, as explained above, the CAPM investment implication is that the only risky portfolio an investor should hold is the market portfolio, and the only supplement to this portfolio should be various investments or short selling of the risk-free asset. This would imply that stock picking and technical trading strategies would be useless and investors should invest only in market indexes or treasury bills. This would also imply that there would be no use for portfolio managers and financial analysts employed by banks since they would add no value.

Due to the simplicity of the assumptions behind the CAPM the model has performed bad in various empirical studies. A more dynamic theory is the Arbitrage Pricing Theory (APT), which is a more general extension of the CAPM, as the CAPM can be shown to be a special case of APT. The APT differs from the CAPM in that it is less restrictive in its assumptions. It assumes that each investor will hold a unique portfolio as opposed to the CAPM where each investor would hold an identical market portfolio. The APT implies that the return of assets can be modelled as a linear function of several factors and not just one as in the CAPM. The various factors have different impacts on the price of an asset, which is represented by a separate beta coefficient for each factor. The beta coefficients are found through linear regression of historical returns. Factors that impact the price of an asset are usually macroeconomic factors such as inflation, Gross National Product, oil and gold prices and interest rates. The APT therefore incorporates the asset prices' historical sensitivity to these factors into the model, and therefore becomes more of an empirical founded theory than the CAPM. If the price of an asset diverges from what the APT would predict, arbitrage should quickly bring the price back to what is expected by the APT. Although APT is more general than the CAPM it still builds on the main assumptions about fully rational investors, and efficient markets that is the foundation of all traditional finance theories. Therefore, as in the case of the CAPM, an empirical study that would prove the existence of a profitable momentum trading strategy would at the same time reject the APT.

2.2 Behavioral finance theory

Behavioral finance as a theoretical field is a relatively new phenomenon within finance theory but is becoming increasingly more acknowledged. Behavioral finance developed as a consequence of some special, grave and seemingly irrational fluctuations in the global stock markets, and uses a more psychological, social and behavioral approach to explain these empirical anomalies. As the empirical evidence supporting these anomalies grew stronger, the inadequacy of traditional finance theory became more and more apparent. Behavioral finance contrasts the traditional finance and economic theories in its main assumptions and methodology and the resulting investor behaviour and aggregate market behaviour is therefore very distinct from the traditional finance framework such as modern portfolio theory. In behavioral finance the decision-making processes of an investor that has to select an investment can be affected by various psychological factors, whether they are professional portfolio managers or private investors. This will sometimes result in irrational investment choices.

Section 2.2.1 will describe the behavioral theories that exist on the psychology and behaviour of the individual investor. Section 2.2.2 will describe the formalized theories that have been developed in order to explain the cause of the empirical anomalies that have been documented in numerous studies. The studies cited in this section will also be empirical in nature, as many of the theories are developed on the basis of empirical analysis.

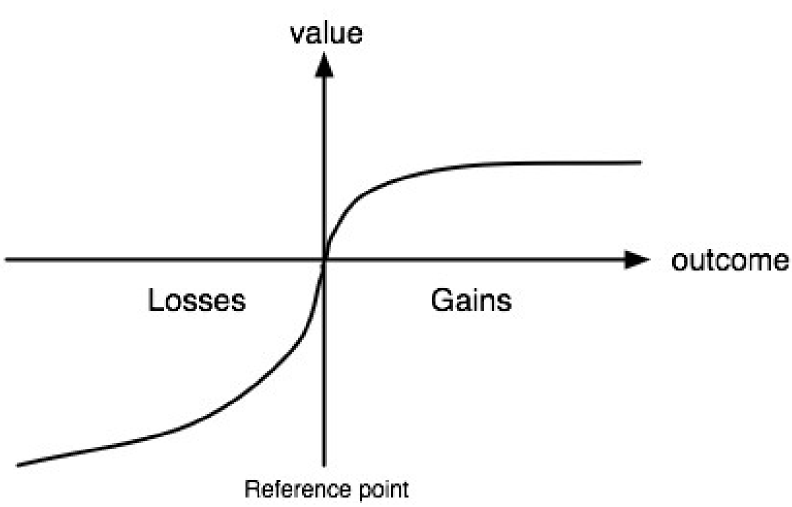
2.2.1 The investor

Prospect Theory

Kahneman and Tversky (1979) developed the Prospect Theory, which provided a necessary theoretical link that could explain the discrepancy between the Expected Utility Theory (described in section 2.1.1.) and the actual behaviour of individuals. Prospect Theory describes the various mental states of an individual, which can have a significant impact on the decision-making process of investors. The study found a “certainty effect” which is an individual’s strong preference for a certain outcome instead of an uncertain outcome although the expected return is the same (This finding is in accordance with the main assumptions of the CAPM model).

The study also documented loss aversion which entails that a given loss has a bigger negative impact on expected utility (or expected value) than a corresponding gain would have a positive impact on expected utility. This implies that investors will exhibit risk-seeking behaviour if their investment is incurring losses and exhibit risk-averse behaviour if their investment return is positive. This phenomenon is called the “reflection effect”. The study found that gains and losses have a different impact on investor’s decision-making process as opposed to a symmetric impact as the Expected Utility Theory hypothesizes. Kahneman and Tversky also found that investors make choices based on relative changes to their wealth instead of applying the absolute change in their total wealth as a decision-making factor. The differently shaped utility curve seen below is a result of utility function that reflects the findings of loss aversion, the “certainty effect” and the “reflection effect”.

Figure 2.3 Loss aversion



Source: http://nudges.wordpress.com, 2008

The utility function is concave for gains and convex for losses, and the curve is steeper for losses than gains. The function has a reference point in the middle from which gains and losses are defined. The reference point can represent an investor's net worth or another measure of wealth, which can be of psychological importance.

The Disposition Effect and the Herding Effect

The Disposition Effect was documented by and described by Shefrin and Statman (1985). It describes how investors are prone to sell off securities or other investments that have increased in price in order to realize the gain and to hold on to securities or other investments that have had a negative decreased in value, as they unwilling to realize a loss. This is due to a regret aversion, which makes the negative impact on utility if you are proven wrong very high. If regret aversion hold true it implies that the linear conditions in the hypothesis on rational behaviour are falsified. The fear of regret has a double impact on the wealth of the investor, as the investor tends to hold on to the losing investment to long as well as selling of the winning investment to early. Regret aversion and the resulting Disposition Effect influences different investors in different ways, and the investors adjust their behavioral patterns and decisions accordingly so that they minimize the impact that regret will have on their utility.

Closely related to the Disposition Effect is the Herding Effect, which describes the tendency of investors to bundle together and restrict from making investment decisions that are significantly different than other investors. According to Koening (1999) this is due to that the impact of losses on utility is not as severe if the investor is incurring this loss with a lot of other investors. Therefore the investor will feel the impact on utility more severe, the further the investor's portfolio deviates from other investors in general or the investors that the individual investor perceives as his or her peer group. The Herding Effect make investors invest in "quality" companies, that have had a historical good performance instead of investing in companies which have not proved to be profitable yet but have good future prospects. This could imply underperformance of these "quality" companies. Many investors are however willing to invest in these "quality" companies as it entails an insurance against regret aversion as opposed to an investment in less known company. If the "quality" performs badly the investor will not feel that he or she would have been able to foresee this, but if the less known company performs badly the investor will feel that he or she should have foreseen the outcome. Herding does therefore not improve the investor's investment decision but gives the investor a false sense of security.

Heuristics

An important element in most financial models is how investors form their expectations about future returns, risks etc. In the Efficient Market Hypothesis it is assumed that all accessible information is priced into securities. This would entail enormous amounts of information being processed and correctly interpreted, which would prove very difficult for individual investors who have to perform complex analyses of complex problems and the future consequences of investments are highly uncertain. Heuristics is a collection of theories concerning various processes that acknowledges this limitation in human mental capacity and describes methods that alleviate this problem of the decision-making process, but at the risk of the optimality of the resulting decision. The investor seeks to reduce the complexity of the problem by applying rules of thumb and other mental short cuts. Heuristics is the general term used for these various mental short cuts and they are used to sort out information and simplify the decision-making process.

Heuristics are valuable tools for investors but can lead to systematic deviations if applied in certain situations. Tversky and Kahneman (1974) argued that investors not always multiply future gains and losses with their respective probability of occurring. Instead investors use heuristic principles to ease the informational requirements. These heuristic principles are approximations and will therefore evidently lead to different deviations and biases. Below are listed the heuristics which are said to influence the decision-making process of investors in the financial market and therefore ultimately could have an impact on financial markets.

<u>Overconfidence</u>

Another psychological phenomenon that is said to influence investor decisions is overconfidence. Overconfidence describes individuals' tendency to overestimate their abilities and their knowledge compared with an average individual. Griffin and Tversky (1993) hypothesized that individuals that are facing tasks of moderate to high difficulty tend to be overconfident in their approach to solve the task, while individuals tend to be underconfident in tasks of uncomplicated difficulty. In addition they find that individuals tend to be overly optimistic when predicting outcomes with a low probability or when predicting outcomes that are determined at random. Griffin and Tversky (1993) also argue that specialists and experts tend to be more overconfident than generalists without a specific expertise in a given line of profession. The existence of overconfidence of investors in financial markets is therefore very likely, as it is made up of individuals trading in the market. Private investors, dealers, financial analytics, portfolio managers and investment advisors are the different individuals who are all (expect private investors) formally educated to perform tasks and make decision in the financial market, but they are also prone to be influenced by overconfidence in their decision-making process. This is because they are experts and specialists who face highly complex problems, and needs to collect and process large amounts of information in order to act and to try and outperform the market. Another contributing factor to overconfidence is that on the stock market there is a low probability of correctly predicting future returns.

Representativeness

Representativeness can be thought of as an excessive attention to the strength of particularly salient evidence, in spite of its relatively low weight (Barberis et al, 1997). Representativeness refers to the tendency of individuals to make decisions based on static and simplified perceptions of the linkage between events and occurrences, thus resulting in imperfect decision-making. Therefore representativeness entails estimation and assessment based on stereotypical perceptions. When individuals form expectations about a future event they often estimate the probability of the occurrence of the future event by the degree to which it is similar to recently observed events, and ignore normative statistical considerations. In financial markets the effects of representativeness could imply that investors overreact to new information as they put to much weight on new information when they form their expectations on future events. Therefore when investors extrapolate recent events into the future, they overweight that is given to recent financially related events also results in an underweighting of long-term averages. (p. 308, Barberis et al, 1997).

Kahneman and Tversky (1974) argues that representativeness is used often in decision-making processes were the probability of object A belonging to class B has to be estimated. They argue that representativeness can result in two forms of biases, which is the “base rate neglect” and the “sample size neglect”. “Base rate neglect” is a bias that results in individuals ignoring accessible information about the actual distribution of an entire population, and instead use their own perceived distribution based on recent events to make a decision. The “sample size neglect” is a bias that results in individuals using a few events as a valid indication of the real distribution of an entire population, thereby ignoring the high variance of small samples.

Conservatism

Conservatism is another important trait in heuristics. The phenomenon conservatism describes how individuals are unwilling to make large changes in their perception of future events, although past and present events are indicating and confirming these large changes. In the financial market this could imply that investors tend to underreact to new information due to the inadequate incorporation of the new information in the decision-making process. In this way the investor only gradually adjust to new information, which would entail lagged price movements on the stock market, as opposed to the immediate response and incorporation of information into prices which would be the result if the Efficient Market Hypothesis is held true.

Biased self-attribution

Biased self-attribution describes how investors who are experiencing high returns on their investments tend to attribute the occurrence of these high returns to their own skills as investors. Thereby investors overestimate the effect of own skills on the return of investment and underestimate the influence of random events that they could not possibly have foreseen.

2.2.2 The market

Overreaction and Underreaction

The investor traits described above could have an aggregate market effect that makes the market behaviour unpredictable and "inefficient" as seen from a traditional finance perspective. This section will focus on theories regarding investor overreaction and underreaction and the aggregate market effect these anomalies have on market prices. Firstly the terms overreaction and underreaction are explained.

The terms overreaction and underreaction implies a comparison with a reaction that is said to be rational. At the same time the term reaction implies that it is a response to an event, which initiates some form of response. When we speak of underreaction and overreaction in the stock market it is the subsequent response to information, which is relevant for the price of a given stock. Such information can be the announcement of accounting numbers, the announcement of a new sales contract or news on potential mergers, acquisitions, stock splits or divestments. But it can also be more macroeconomic news, which affects the stock market in general such as interest rate hikes, the publication of consumer price numbers or employment numbers.

The rational reaction to such new information is according to the Efficient Market Hypothesis a rapid and correct incorporation of the new information into the price of a given stock. But what a correct response includes is often open to interpretation. But in general the correct incorporation of new information is evident in a quick change in a stock's price, which should be identical to the difference in the company's fundamental value, which the information has caused.

According to the Efficient Market Hypothesis the information cannot cause changes in the stock price over a long period. This entails that by analyzing past information one should not be able to predict the future price changes of the stock, because the information is already incorporated into the price of the stock. If the information is not incorporated into the price, the initial reaction from investors to the information has been incomplete and then the terms underreaction and overreaction become relevant. If it is assumed that the market overreacts then the immediate reaction to the new information causes a large change in the price of the stock, and if the market underreacts the immediate price correction is not large enough.

The influences of overreaction and underreaction on price behaviour in the financial markets have been used to explain the empirical observation of long-term reversal and momentum in the prices of stocks. This is because an overreaction will result in prices that are either too high or too low and prices will therefore be reverting back as soon as the market acknowledges that prices are driven by overreaction. On the other hand if prices are drive by a continuous underreaction this will result in momentum, which means that prices keep increasing or decreasing as long as investor keep underreacting to information.

Research literature within behavioral finance concerning underreaction and overreaction has had different approaches. Some studies focused on overreaction as the primary consequence of cognitive and heuristic errors made by investors, others focus on underreaction and some unify underreaction and overreaction into a combined theory.

In 1985 De Bondt and Thaler made a study of the profitability of a contrarian investment strategy that bought past losers and sold past winners. The research in their paper gave evidence to significant long-term price reversal of stock prices. The empirical research was based on monthly CRSP data in the period of 1926-1982 and stocks were assigned to a ”winner” or “loser” portfolio based on the prior 3-6 year returns of the stocks. Analysis of the data showed that “loser” stocks with low returns in the past tended to outperform “winner” stocks with a significant 24.6 percent (this is the cumulative average residual) 36-months after portfolio formation. Interestingly the effect is asymmetric so that stocks with low past returns outperform the market by 19.6 percent and stocks with high past return only underperform the market by 5 percent (p. 799, De Bondt and Thaler, 1985). De Bondt and Thaler base their theoretical explanation of this phenomenon in the world of psychology and investor behaviour. They hypothesized that an overreaction of investors to unexpected information or dramatic news events, which in effect contradicts Bayes' Theorem[2], affects stock prices and causes long-term stock price reversal. They also argued that investors overreact to good as well as bad news, which implies that companies, which has delivered bad news will be "oversold" and companies that deliver good news will be "overbought". The linkage between the theoretical cause of investor overreaction and the effect of empirical long-term reversal of stock prices was strong and intuitive and the De Bondt and Thaler (1985) study was one of the first studies that challenged the Efficient Market Hypothesis.

Barberis et al (1997) developed a widely cited behavioral finance model (referred to as the investor conservatism bias model) that assumes that investors do not exhibit the behaviour that would otherwise be implied if the Efficient Market Hypothesis were to be true. They try to explain through this parsimonious model how the aggregation of investor sentiment results in the continuation of stock prices in the intermediate term and reversal in the long-term. The model is driven by the assumption of representative heuristics (representativeness is explained in *section 2.2.1, Heuristics*), which implies that investors put to much emphasis on recent data thereby disregarding an approach that encompasses the broader statistical evidence on stocks and stock markets. This results in overreaction and long-term stock price reversal.

Conservatism (conservatism is explained in *section 2.2.1, Heuristics*), as an investor trait, is also used to explain why investors fail to incorporate and update new information into their decision process, which results in underreaction and intermediate-term price momentum. The more elaborate model implication is that in the process of investors forming expectations about future earnings skewness in investor expectations occurs. Investors either expect future earnings and therefore also future prices to follow a steady trend or to be mean-reverting, but they expect future earnings to be mean-reverting with a higher probability. In model reality actual earnings are assumed to follow a random walk. The skewness in investor expectations results in "…underreaction to news, and overreaction to consistent good or bad news." (p. 27, Barberis et al, 1997). This is because a string of good or bad results will confirm the investors

[2] Bayes' Theorem is a simple mathematical formula used for calculating conditional probabilities. It is build on the assumption that rational belief is governed by the laws of probability.

believe in a trending market. For example after a string of positive earnings the next earnings result has an equal probability of being positive or negative, but because investors already have been confirmed in their belief of a trending market, they will react more to a negative earnings result because this is not what is expected. This results in the next average return being negative due to overreaction. The opposite holds following a mean-reverting market. Because investors now expect earnings result to reverse, they will underreact when an earnings result confirming their belief of a mean-reverting market is announced, and this underreaction results in price momentum.

Hong and Stein (1997) also use underreaction and overreaction to explain price momentum and long-term reversal. In their paper they use two investor types, “newswatchers” and “momentum traders”, to model an asset market. Both investor types have bounded rationality, which means that investors are not able to incorporate all the available information in their decision-making process (as opposed to the assumption of fully rational investors in the CAPM and the Efficient Market Hypothesis), but instead only are able to process a subset of the overall information set. The bounded rationality of the “newswatchers” effects their interpretation and thereby their investment reactions to private information. As they are not able to fully consider all the information available at one time and as the private information is gradually obtained by different “newswatchers” a lag effect arises and causes prices to underreact in the short run (this is what Hong and Stein refer to as the “gradual-information-diffusion model”), but the underreaction spur on the “momentum traders” to earn a profit by chasing the trend. A distinction is made between “early momentum traders” and “late momentum traders”, and “early momentum traders” is said to create the initial momentum, which encourages “late momentum traders”, which reinforces the momentum effect and translates into an overall market overreaction.

Another acknowledged theoretical model concerning underreaction and overreaction was developed by Daniel et al. (1998). They argue that some investor decisions are influenced by the two types of investor traits: overconfidence and biased self-attribution (both terms are described in detail in *section 2.2.1, Heuristics*) and that this investment behaviour has a measurable impact on security prices. Overconfident investors tend to overreact to private information and underreact to public information according to the theory. This results in short-term price momentum and long-term price reversal.

Distinct from other theories about under- and overreaction in security markets Daniel et al. argue that: "…positive return autocorrelations can be a result of continuing overreaction" (Daniel et al., 1998, p. 1865). Due to biased self-attribution investors also tend to misjudge the factors (e.g. an investor reasons that his or hers high return on his portfolio is owing to his or hers skills as an investor instead of other factors such as luck, market movements etc.) contributing to their prior investment outcomes, resulting in more overconfident investors. This results in positive short-lag autocorrelation (short-term price momentum), whereas overconfident investor behaviour results in negative long-lag autocorrelation (long-term price reversal) and excess volatility in stock prices. As the model assumes overconfidence is based on the production of private information they argue that in companies were information asymmetry is pronounced (private and small companies), the under- and overreaction effect will be larger. Daniel et al. does not attempt to classify overconfident investors into a certain investor category such as institutions, small individual traders or investment professional but suggest this categorization as a future field of research.

Robustness check of behavioural market models and anomalies

Hong et al. (2000) empirically test the findings of the gradual-information-model developed by Hong and Stein (1997), in order to clarify the usefulness and predictive power of the model. Previosly Fama (1998) had raised critique of the behavioral models of Hong and Stein (1997), Barberis et al. (1997) and Daniel et al. (1998) by stating that models that simply rationalize existing patterns that they were designed to capture are not too impressive. As a reply to this critique Hong et al. (2000) do an out-of-sample test of the gradual-diffusion-model by examining the hypothesis that states that momentum should be stronger in those stocks where the private stock-specific information travels slowly.

They report three key findings in their study. First of all, the size of firms seems to be very inversely correlated with the profitability of momentum strategies if the smallest stocks are left out of the test sample. Secondly, stocks with low analyst coverage are reported to be more profitable when incorporated in momentum strategies, than stocks with high analyst coverage (this result is reported when holding size fixed). Finally, analyst coverage as factor for momentum seems to have more predictive power for past losers than past winners. All the findings give evidence to support the model's predictive power as they show how momentum is stronger in stocks where the information travels out more slowly.

The behavioral finance models developed by Hong and Stein (1997) and Barberis et al. (1997) were empirically tested by Doukas and McKnight (2005). Their empirical sample is put together by data from 13 different European stock markets during the 1988-2001 period. The results of the study confirm what the gradual-information-diffusion model of Hong and Stein (1997) and the investor conservatism model of Barberis et al. (1997) predict about stock price behaviour. Therefore the gradual dissemination of firm-specific information and investor's failure to correctly update their beliefs sufficiently when receiving new public information are both identified as main contributing factors of price momentum in this study. Both the predictive models assume an initial underreaction by investors and subsequently investors correct for this underreaction.

Doukas and McKnight documents significant intermediate-term price momentum in 8 out of the 13 European stock markets examined. They find that price momentum stocks in these 8 stock markets are related to their size and amount of analyst coverage received and when holding size fixed stocks with low analyst coverage exhibit stronger price momentum characteristics then stocks with high analyst coverage. This evidence supports the gradual information diffusion theory of Hong and Stein (1999). In favour of the investor conservatism bias of Barberis et al. (1997) they are able to document that investors fail to accurately update their earnings forecast of firms, as new public information becomes available resulting in price momentum. This they deduct from the evidence that shows that analysts' forecast dispersion and the profitability of momentum strategies is inversely related.

Fama and French (1993, 1996) use a three factor model to explain and capture the pricing anomalies observed on various stock markets, which is not captured by the otherwise widely applied Efficient Market Hypothesis developed by Fama (1965, 1970) and Samuelson (1965) and the Capital Asset Pricing Model developed mainly by Sharpe (1964) and Lintner (1965). The three factors Fama and French include in their model is:

- the excess return on a market portfolio (R_m-R_f)
- the difference between the returns on a portfolio of small stocks and a portfolio of large stocks
- the difference between the returns on a portfolio of high-book-to-market stocks and a portfolio of low-book-to-market stocks.

Fama argues that the model can explain the long-term mean reversal of stock prices previously documented by De Bondt and Thaler (1985), however they model cannot explain the continuation of 3-12 month returns observed by Jegadeesh and Titman (1993) in the 1963-1993 period in NYSE, AMEX and Nasdaq stocks.

In a later study Fama (1998) tests the Efficient Market Hypothesis against the stock price anomalies of intermediate-term momentum and long-term reversal. Fama argues that underreaction to stock prices is as common as overreaction and that the quantity of evidence long-term reversal and intermediate-term momentum is equally distributed, which shows that they are in fact just reaction anomalies that market efficiency eventually corrects for. He states: "The expected value of abnormal returns is zero, but chance generates apparent anomalies that split randomly between underreaction and overreaction" (Fama, 1998, p. 287). Fama also states changing the methodology in research studies of long-term reversal has made the anomaly disappear, which could be evidence of data snooping in earlier studies. As in the previous studies (Fama & French, 1993, 1996) Fama is unable to explain the intermediate-term continuation in stock prices documented by Jegadeesh and Titman (1993), but also the findings of Chan et al. (1996) survives Fama's robustness check.

2.3 Summary

The theory section gave an overview of the traditional finance theories and the behavioral finance theories. Focus was on the assumptions about investor behaviour and the resulting aggregate market. The different assumptions about investor behaviour inherent in the traditional finance framework and in the behavioral finance framework result in different markets.

In the traditional finance framework it is assumed that investors are perfectly rational agents that are maximizing utility and that they have the appropriate amount of information to make decisions that can maximize their utility. Investors are prone to decision-making errors but these errors are of a random nature and not a systematic nature, as this would lead to market trends. The aggregate market result of the investor behaviour assumed in traditional finance literature is efficient stock markets in which stocks are always priced correctly according to the information that is available about the fundamentals of the companies. If new information arrives this is immediately incorporated into the price of the stock. According to the Efficient Market Hypothesis there are three forms of market efficiency; weak, semi-strong and strong. The difference between the market efficiency is the amount of information, which is reflected in security prices. The Capital Asset Pricing Model is a widely applied finance model that indicates the relationship between return and risk for assets. It is used for pricing securities and it is build around assumptions of investor rationality and efficiently functioning capital markets.

In behavioral finance the assumptions of investor behaviour are different. Prospect Theory describes how investors exhibit loss aversion, which implies that gains and losses affect investor utility different and thereby also the behaviour they exhibit if they are experiencing gains or losses. The Dispositon and Herding effect explain observed investor behaviour irregularities with psychology. Investors are unwilling to sell of securities that are “out of the money” as they would have to realize their loss, and quickly sell of securities that are “in the money” as they are eager to realize their gain. Investors also tend to make decision in bundles as it provides the investor with the security of knowing that if their investment decision is wrong, the investment decisions of many other investors are also wrong. Overconfidence, representativeness, conservatism and biased self-attribution are all different investor traits in behavioral finance classified as heuristics. Heuristics are psychological processes that investors make use of in their decision-making process in order to make the process less complex and reduce the amount of information needed in order to make an investment decision.

The aggregate market result in behavioral finance of the different investor assumptions is the numerous observed market anomalies that have been empirically proven to exist. This section focused on the underreaction/overreaction anomaly from which different market theories have been developed. The theories explain how investor underreaction in the intermediate-term and overreaction in the long-term leads to momentum and thereby the continuation of security prices in the intermediate term and long-term reversal of prices. Investor traits such as representativeness, conservatism, overconfidence and biased self-attribution are used to explain how investor behaviour affects the aggregate market movements. Finally the various empirical tests made on these behavioral finance theories are described. Mostly the theories are found to be robust to empirical testing, especially intermediate-term momentum.

3. Momentum strategies

In the previous sections the term momentum has briefly been introduced. Momentum describes certain price behaviour of stocks, as it is the continuation of stock price movements. A formal definition of price momentum is the persistence of observed past price change. The existence of price momentum and the duration and magnitude of price momentum has been documented in a series of empirical studies conducted on stock markets in different countries and continents. Momentum as a price phenomenon has been empirically proven to exist on the US market, various European countries and the Indian stock market.

Strategies that try to exploit momentum in stocks are referred to as momentum strategies or relative strength strategies. Momentum strategies are divided into formation periods and holding periods. The formation period is where the stocks are ranked form high to low based on their past returns. The intuition behind the strategy is that the stocks that have performed well in the past will continue to perform well in the future and therefore you should invest in these stocks. Conversely, stocks that have performed poorly in the past will continue to perform poor in the future and therefore you should not invest in these stocks, or take a short position in these stocks and exploit the expected decrease in price. The holding period is the period in which you hold your momentum stocks. The formation period and holding period can vary in length but as momentum has been most prevalent in the intermediate term (3-12 months) the length of formation periods and holding periods are usually within this range.

The following subsection will deal with the most important empirical studies made on intermediate-term momentum. The empirical studies that have identified momentum in different markets using different data samples will be described and the findings explained. An important distinction is to be made between price momentum and earnings momentum. Price momentum focuses on the continuation of stock prices, which will the focus in this thesis, where as earnings momentum focuses on the continuation of positive or negative earnings announcements. The term momentum will in this study mean price momentum so there can be no mixing of the two momentum terms.

3.1 Empirical studies: intermediate-term momentum

In Jegadeesh and Titman (1993), which is the benchmark study of this Master thesis, evidence is provided of a strategy that generate significant positive returns based on historical US stock market quotes, while applying holding periods of 3-12 months. Jegadeesh and Titman does not attribute these positive returns to differences in systematic risk factors between past winner and losers or delayed stock reactions to common factors, but instead suggest that price momentum occurs due a delayed price reaction to firm-specific information. They also observe that the positive return generated by the momentum strategy evaporates in the following to years after the holding period. The data used in this empirical study was based on an extensive data set of 24 years of prices on American stocks (listed on the NYSE and AMEX exhanges). They rank the stocks into 10 decile portfolios on the basis of the prior returns, which is the portfolio formation period. The top decile portfolio is denominated the "winner" portfolio and the bottom decile portfolio is denominated the "loser" portfolio.

The overall portfolio strategy consisted in buying the "winner" portfolio and shorting the "loser" portfolio every time the respective holding period expires. Jegadeesh and Titman followed an equal-weighting strategy so that each stock represented an equal amount of market value in the total sample of stocks throughout the period. 16 different strategies were followed by combining different holding and formation periods (3-month, 6-month, 9-month and 12-month), but most focus was based on the strategy which picked stocks based on their past 6-month returns and had a holding period of 6-months, which proved to generate a return of around 1 percent a month (the most profitable strategy consisted of 12-month formation period and 3-month holding period resulting in a monthly return of 1.49 percent). The findings show an anomaly in the US stock market, which is difficult to explain although many attempts have been made. This thesis will to a large extend replicate the methodology of the Jegadeesh and Titman (1993) paper and apply it to Danish stocks. Rouwenhorst (1998) is one of the few who has done this before, but this study only applied Danish stocks as part of a larger European sample and did therefore not delve into the specific price momentum characteristics of the Danish stock market.

6 years later Jegadeesh and Titman (1999) evaluate their earlier findings by the use of a new data set, which is based on the stock prices of the subsequent 8 years of the Jegadeesh and Titman (1993) sample. They still find considerable and similar momentum profits with the use of the new data, which can counter argue the many claims set forward on data mining or data snooping. They also test the data to see if momentum profits can be contributed to a delayed overreaction by investors, which is eventually reversed as the behavioral finance models of Barberis et al. (1997), Daniel et al. (1998) and Hong and Stein (1997) has indicated. Jegadeesh and Titman do this by analyzing post-holding returns. They document abnormal negative post-holding returns in the 13 to 60 months after the formation period, which gives

evidence to support that momentum profits a generated by a delayed overreaction, an argument which is supported by the behavioral finance models previously mentioned. On the basis of this analysis they also reject that documented momentum profits can be explained by a cross-sectional dispersion in expected returns, an argument that Conrad and Kaul (1998) supported. However the evidence should be cautiously interpreted as they only find significant return reversals the long-term horizon of 4 to 5 years and not in the 2 to 3 year horizon.

Rouwenhorst (1998) examined the profitability of momentum strategies across 12 different European countries including Denmark using data from 1980 to 1995 and replicating the portfolio formation and holding periods applied in the study of Jegadeesh and Titman (1993). He found a significant difference in intermediate-term returns (more than 1 percent a month after correcting for risk) between past-winners and past-losers in an internationally diversified portfolio constructed from stocks within these 12 different European countries. Rouwenhorst also suggests on the basis of his findings that return continuation is stronger in smaller firms than large firms and that price momentum can be traced back to a common price momentum factor, due to the correlation of relative strength strategies in American and European stock markets.

The following year Rouwenhorst (1999) makes an analysis of local return factors in emerging stock markets, which is preoccupied with momentum as one of the return factors and is an extension of his earlier work on the subject. Rouwenhorst made use of the Emerging Markets Database of the IFC for this study in which 1750 firms in 20 different emerging countries were used over a period sample of 22 years (1975-1997). He finds that "the factors that drive cross-sectional differences in expected stock returns in emerging equity markets are qualitatively similar to those that have been documented for developed markets" (page 1439, Rouwenhorst, 1999). One of the significant factors is price momentum and the documentation of the existence of price momentum in emerging markets shows that this phenomenon exists across different national borders and macroeconomic conditions.

Dijk and Huibers (2002) replicate the methodology of Rouwenhorst (1998) and base their analysis of price momentum on stock data from 15 European countries (including Denmark) in the period 1987-1999. Their findings are consistent with Rouwenhorst's (1998) and document that price momentum strategies are profitable in the intermediate-term across European markets also after correction for stock-related risk, book-to-market and size effects. They link the reporting of stock analyst behaviour and their underreaction to new information and the continuation of stock return in the intermediate-term and suggest further research on stock analyst behaviour and price momentum.

Same observation is made by Griffin et al (2003) in a study, which includes international data from 40 countries with different macroeconomic conditions. Griffin et al find no statistical evidence to support claims that price momentum and macroeconomic risk is linked. Two models, an unconditional model and a conditional forecasting model are used to determine if macroeconomic risk variable can explain momentum. Following price momentum seem to be present in all macroeconomic states no matter what the GDP growth is or the aggregate stock movement and the reversal of momentum profits is also documented in the study.

In 1999 Moskowitz and Grinblatt (1999) approached the price momentum anomaly from an industry perspective. The data used is from the period 1963 to 1995 using American stock quotes, and industry classifications are based on the Standard Industry Classification (SIC) codes as obtained from the same database as stock prices are retrieved from (CRSP). They document strong industry effects as a main driving factor of individual stock momentum, and therefore if a strategy that buy past winners and sell past losers is controlled for industry momentum, the strategy will be much less profitable. Moskowitz and Grinblatt argue that from this insight follows that relative strength strategies are much more risky than earlier expected, due to the fact that past winners and past losers tend to be bundled in the same industries. They use the behavioral finance theory of herding as an explanation to why industry momentum appears.

Grundy and Martin (2001) find momentum in US stocks in the period of 1926-1995 using the standard approach of picking the top-performing stocks of the market and shorting the worst performing stocks of the market on the basis of total return of the individual stocks. They report a risk-adjusted monthly return of 1.3 percent to support this claim. Grundy and Martin also reports that a momentum strategy which pick stocks on the basis of formation period stock-specific returns are more profitable than if you select stocks on the basis of total stock return (page 72, Grundy and Martin, 2001). Two factor models (a two-factor asset pricing model and the three-factor Fama-French model described in Fama and French (1993)) are used to decompose the stock returns in to stock-specific returns and factor returns. An important empirical finding is that a momentum strategy in the period 1966-1995 would have earned a monthly return of more than 1.3 percent after the return has been risk-adjusted according to the Fama-French three-factor model. The study suggests that neither industry effects nor cross-sectional variation are primary factors that can explain price momentum and that a strategy that ranks stocks on the basis of stock-specific returns would outperform a strategy using total stock returns to rank stocks.

Chan et al. (1996) use a sample of stocks listed on NYSE, AMEX and Nasdaq running from 1977 to 1993 and rank stocks both according to their past returns as well as ranking them by the use of a specific measure of earnings news. They find that spread of 8.8 percent (15.4 percent) over a period of 6 months (12 months) can be found between stocks with a high prior 6-month return yields and stock with a low prior 6-month return yield. Similarly a spread of 7.7 percent (9.7 percent) is found over a period of 6 months (12 months) when stocks with a high and low moving average of past earnings estimates are compared. Price momentum is therefore found to have the overall largest effect and cannot be explained by earnings momentum: "…the price momentum effect from prior return tends to be stronger and longer-lived than the earnings momentum effect from past earnings surprise" (Chan et al., 1996, p.1709). But Chan et al. still use both past returns and past earnings surprises to explain the momentum drift effect. Market risk, size and book-to-market effects are controlled for and are found to have little explanatory power of price momentum. Instead under-reaction and slow response to new information by the market is suggested as a more meaningful explanatory factor.

As a counterargument to the underreaction hypothesis Lewellen (2002) claims to document that price momentum is not caused by underreaction to information. Instead Lewellen stress that excess covariance between stocks are the main cause to price momentum, based on the findings of his study which shows that stocks co-vary across industry, size and value factors. The rejection of firm-specific returns as the cause of price momentum supports the results of Moskowitz and Grinblatt (1999), but still many other studies argue that firm-specific returns drive price momentum. The data used for the study is from the NYSE, AMEX and Nasdaq exchanges in the period of 1941-1999. On the basis of his findings Lewellen develops a model, that is based on the main assumption that investors do not know the true distribution of stock returns, and instead they estimate stock returns from past return data and continuously update their perception of the return distribution as new data become available. This implies that past returns may show correlation patterns, even though investors are fully rational and make rational decisions based on their estimate of the return distribution. This model can explain overreaction and return continuation in stock returns if investors are overconfident in their past beliefs.

An extensive empirical study on price momentum in UK stock market was carried out by Liu et al. (1999). The period examined is 1977-1996, two different stock samples are used and the results are controlled for size, systematic risk, book-to-market ratio and cash-earnings-to-price ratio. The three-factor model of Fama-French is also used for control. Significant momentum effects were documented and the effects could not be attributed to common factors, which lead Liu et al. to conclude that industry or idiosyncratic components of stock returns must be able to explain price momentum, which confirms past assumptions of delayed reaction to industry or stock-specific information as the decisive momentum factor.

Conrad and Kaul (1998) examined which strategies based on returns would have proven to profitable over different periods using historical stock prices. They examine 120 different strategies using 8 different investment horizons and less than 50 percent of the strategies prove to be profitable. Again momentum strategies are found only to be profitable using a intermediate-term investment horizon (3-12 months). They use NYSE and AMEX-listed securities in the period 1926-1989 including various sub-periods to control for time-varying properties of the market. Out of the 120 strategies examined 55 prove to be statistically significant profitable. Out of these 55 strategies 30 are momentum strategies and 25 are contrarian strategies. Interestingly momentum strategies were not profitable in the period 1926-1947 while contrarian strategies were very profitable during this exact period. This could be due to the financial turbulence created by The Great Depression of the early 1930's and the repercussions of the two Great World Wars. Another main finding of this study is that there is no discernible time-series variation in returns and that instead cross-sectional variation in mean returns seems to be the most important factor to the profitability of momentum strategies and the failure of contrarian strategies. This would imply price momentum strategies are dependent on common market variation in order to prove profitable and that increased risk is the explanation to why momentum strategies can prove to be profitable.

Lee and Swaminathan (2000) use the trading volume of stocks to examine the influence this factor has on price momentum. Data used for the paper is from the1965-1995 period and based on all the stocks listed on the AMEX and NYSE stock exchanges in this period. Their findings suggest that the relationship between stocks with a high trading volume and price momentum characteristics in these stocks is a complex relationship. Lee and Swaminathan show that turnover as a measure of trading volume only fuels price momentum for past losers and that turnover also helps information diffusion for past winners (information diffusion results in a gradual response to information (underreaction) and causes further price momentum). They also document that trading volume has some predictive power over the timing of the long-term reversal in that stocks with a high trading volume exhibits a faster long-term reversal. But Lee and Swaminathan conclude that trading volume has significant predictive power of a stock's price momentum cycle and therefore partly dismiss the price momentum models developed by Hong and Stein (1997), Daniel et al. (1998) and Barberis et al. (1997) as none of them incorporate trading volume as a determining factor of price momentum. They develop their own hypothesis ("momentum life cycle hypothesis") to explain how trading volume can predict where a stock is in it's momentum life cycle and they elaborate: "When stocks decline in popularity, their trading volume drops and they become neglected. When stocks increase in popularity, their trading volume increases" (Lee and Swaminathan, 2000, p. 2066). They also state that their study implies that stock prices deviate from fundamental values, which contradicts the Efficient Market Hypothesis and that "… the market is better characterized as being in a constant state of convergence toward intrinsic value" (Lee and Swaminathan, 2000, p. 2066). This constant state of convergence is argued to apply to intermediate underreaction as well as long-term overreaction.

Glaser and Weber (2003) also analyze price momentum in relation to turnover but use data obtained from the German stock market for their study. The data set is comprised of 446 listed on the Frankfurt Stock Exchange and daily and monthly closing prices are used to calculate the returns in the period 1988-2001. Daily data on the numbers of shares traded for each stock is used to categorize stocks into high- and low-turnover stocks. The Jegadeesh and Titman (1993) methodology is to a large extend followed but instead of 10 portfolios, Glaser and Weber use only 5 portfolios to rank the stocks on the basis of their return. Glaser and Weber documents that stocks with a high turnover have a higher price momentum effect, than stocks with a low turnover. Size, book-to-market and industry-factors also contribute to price momentum but to a lesser extent than turnover. Although they find momentum strategies to be profitable the turnover factor has no predictive power among stocks with a large market capitalisation according to their empirical analysis. This entails that momentum strategy should focus on small capitalisation stocks, which are more illiquid and therefore also costly to trade. The high frequency of trading involved when following a momentum strategy could evaporate the profits, due to the heavy transaction costs involved when small capitalisation stocks are frequently traded.

Relative few studies have been made on price momentum in the Asian stock markets, but Sehgal and Balakrishnan (2008) examines if price momentum characteristics are evident in the Indian equity market. They use a sample of 452 companies that are listed on the Bombay Stock Exchange and part of the index representing the 500 largest stocks on this exchange. The time period examined runs from 1990-2003. Sehgal and Balakrishnan find momentum patterns in the sample. The momentum profits cannot be captured by the Capital Asset Pricing Model, however the Fama-French three-factor model completely explains the reported momentum profits, individual stock momentum as well as the various characteristic-sorted portfolios. This implies that the momentum profitability on this equity market has a rational explanation owing to the risk factors of the Fama-French three-factor model. The evidence stands in stark contrast to the evidence generated by momentum studies conducted in the US stock market and various European stock markets, where the profitability of momentum strategies cannot be explained by risk factors. This could imply that the Indian stock market is more efficient to incorporate information, or it could imply that more developed stock markets are also more complex, and therefore need more complex models to decompose and capture the momentum profits correctly.

Inspired by the stock characteristics identified by D´avolio's (2002) paper on short sales, Ali and Trombley (2006) develop their own index on the basis of these characteristics (firm size, share turnover, cash flow, IPO status and book to market ratio) as a measure of short sales constraints. Ali and Trombley then use stock price and return data from the period 1984-2001 on NYSE, AMEX and Nasdaq securities to measure the effectiveness of their index as a measure of short sale constraints, and they also check for if significant price momentum characteristics can be found in the sample by following the Hong et al. (2000) methodology. The index is found to be positively correlated with main indicators of short sale constraints such as short interest and option-implied short sale of costs and negatively correlated with future stock returns, and momentum is found to be significant in the sample period. After the robustness of the index has been documented they examine the link between short sales constraint and momentum in the sample period and find a positive correlation. Momentum profit for the stocks in top quintile of the index (and thereby the 20 percent of the stocks in the sample facing the most short sales constraints) was a monthly 1.83 percent as opposed to the momentum profit of 0.14 percent a month for the bottom quintile stocks. Interestingly stocks which are past losers seems to almost entirely be the contributor to the documented momentum profits, which is in contrast to prior findings, as 1.45 percent of the 1.69 percent difference (1.83 percent - 0.14 percent) is due to stocks that have experience the lowest past returns.

George and Hwang (2004) documents that the 52-week high price connected with current price of stock can explain a large fraction of the profitability arising from following a return-based momentum strategy. In the study they follow three separate momentum trading strategies. The first strategy buys the top 30 percent of past winner stocks and goes short in the bottom 30 percent of past loser stocks and thereby follows the Jegadeesh and Titman (1993) methodology. The second momentum strategy follows methodology proposed by Moskowitz and Grinblatt (1999) and take long positions within the top 30 percent performing industries exhibiting strong momentum and short positions in the bottom 30 percent of the industries with weak momentum based on past industry returns. The third strategy buy stocks that are close to their 52-week high price and sell stocks that are from their 52-week high price. The data used is similar to that in Moskowitz and Grinblatt (1999) although 6 years of additional data has been included (1963-2001). Monthly returns are used to measure past 6-month performance and a holding period of 6 months is used for all the three strategies. George and Hwang control the returns for size and bid-ask spreads. They document returns that are twice as high for the third strategy as those obtained by following the two other strategies. On the basis of this finding they argue that the 53-week high price of stock is a better indicator of future returns than a stock's past return, as the 52-week high measure is a successful indicator of future continuation of returns despite the various past return patterns of stocks. George and Hwang does not find long-term reversal when past performance is measured on the nearness to the 52-week high price and argues that intermediate price momentum and long-term reversal should be seen as to distinct phenomena, instead of a univariate phenomenon.

Scowcroft and Sefton (2005) use a market capitalization-weighted momentum portfolio and examine the cause of momentum with a new approach. They use the large-cap index of MSCI, which includes global stocks from 23 developed countries around the world. The index includes around 1300 stocks and two sample periods (1992-2003 and 1980-2003) are being examined in the study. Their findings resulting from their analysis of the value-weighted strategy shows that price momentum is caused mainly by industry effects as previous research have also indicated (Moskowitz and Grinblatt, 1999). They control for cross-section variation in industry mean returns, or a variation in the risk of the different industries and find that these are not significant factors. Their study also indicates that for small-cap stocks the individual effect becomes a more important momentum factor.

3.2 Summary

This section introduced the definition of the momentum and described the intuition of momentum strategies. Momentum strategies try to exploit past price movements in stocks and thereby make a profit. The various empirical studies that document the profitability of such strategies by analyzing past stock market data was then described. The study made by Jeegadesh and Titman (1993) was the first to document the profitability of a momentum strategy in the intermediate-term, and the methodology of this study will to a large extend be replicated and applied on a different data set in the following section. All the studies find that momentum strategies are profitable in the intermediate-term, but the cause of the profitability of momentum strategies are being attributed to different factors. Industry, size and risk are just some of the factors that have been used to explain the documented profitability, but consensus on what causes price momentum is far from being reached. None the less the finance literature is abundant with empirical findings that shows that momentum profits is more than just a temporarily market anomaly. Below the findings of the most important momentum studies are summarized.

Table 3.1 Summary of Findings in Momentum Literature

Authors	**Year**	**Country/ Region**	**Stock Data**	**Sample period**	**Summary of principal findings**
Jeegadesh & Titman	1993	USA	NYSE and AMEX	1965-1989	- Delayed price reaction to firm specific information.
Chan, Jeegadesh & Lakonishok	1996	USA	NYSE, AMEX & Nasdaq	1977-1993	- Price momentum is significant and cannot be explained by earnings momentum.
Rouwenhorst	1998	Europe	2,190 companies in 12 different European countries	1980-1995	- Momentum profits in all 12 countries. - Momentum profits are driven by a common component.
Rouwenhorst	1999	Africa, Asia, Europe & South America	1,750 companies in 20 different emerging market countries	1975-1997	- Price momentum factors in emerging markets similar to those in developed markets.
Moskowitz & Grinblatt	1999	USA	NYSE, AMEX & Nasdaq	1963-1995	- Industry momentum strategies more profitable than industry neutral strategies.
Liu, Strong & Xu	1999	UK	London Stock Exchange	1977-1996	- Strong momentum effects in the UK stock market.
Jeegadesh & Titman	2001	USA	NYSE, AMEX & Nasdaq	1965-1998	- Findings consistent with the 1993 study.
Grundy & Martin	2001	USA	NYSE, AMEX & Nasdaq	1926-1995	- Industry effects not the main cause of momentum profits.
Dijk & Huibers	2003	Europe	15 different countries	1987-1999	- Price momentum strategies profitable across European markets.
Griffin, Ji & Martin	2003	Africa, Asia, Australia Europe, North America & South America	12,276 companies in 40 different countries	1926-2000	- Price momentum profits are large in most countries.

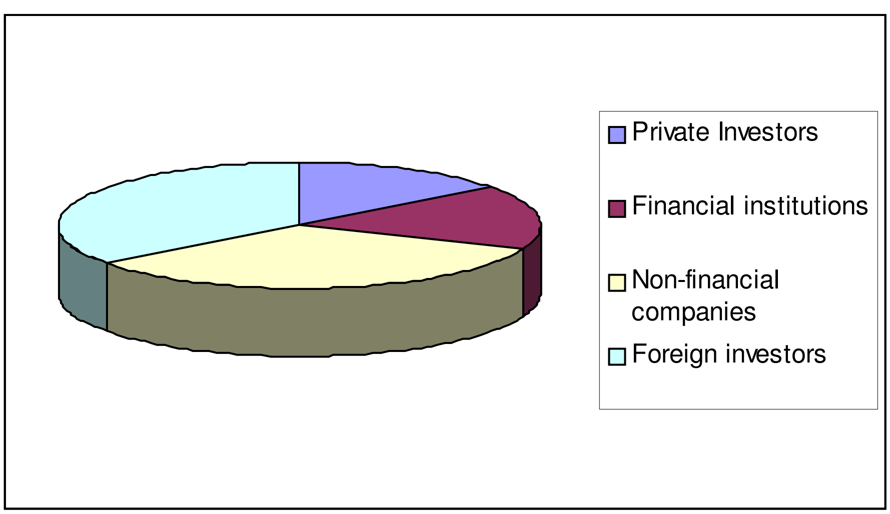
4. Empirical momentum study on the Danish stock market

In the following section an empirical test based on data from the Copenhagen Stock Exchange will be completed in order to possibly identify the existence of the price momentum phenomenon in the Danish stock market. Firstly the characteristics of the Danish stock market will be described. Then the data and methodology applied in the empirical study will be described and explained. Finally the empirical results will be presented

4.1 The Danish stock market

The Copenhagen Stock Exchange is the place in Denmark, were securities are listed and traded as well as bonds, treasury bills and notes, and financial futures and options. At the beginning of July 2008 there were 245 companies listed on the Copenhagen Stock Exchange. The vast majority of those are Danish companies, which is a relatively high number compared with the size of the Danish economy. This stems form the fact that many of the Danish listed companies are small-cap companies compared to companies listed on other international exchanges. Small and intermediate-sized companies characterize the Danish business environment and there is a common tradition of achieving funding through bank loans and mortgage credit financing. Industry is the largest sector represented on the Copenhagen Stock Exchange. The total market value of the companies listed on the Copenhagen Stock Exchange was DKK 1,405 billion in the beginning of July 2008 and the turnover on the equity market totalled DKK 493 billion and around 900,000 equity trades were executed. The ownership distribution of Danish listed stocks can be seen in *figure 4.1* below.

Figure 4.1 Stock ownership distribution



As the figure shows most of the Danish listed stocks are distributed between non-financial companies and foreign investors, while private and financial investors holds about 15-16 percent of the Danish stocks each.

Since 2005 the Swedish company OMX has owned the Copenhagen Stock Exchange, which also own stock exchanges in other Nordic and Baltic countries. In February 2008 OMX became a part of the NASDAQ OMX Group. The OMX C20 index is the index with the 20 most actively traded shares, and the index is updated semi-annually. The C20 index accounts for around 75-80 percent of the total (index weighted) market cap of the 245 companies listed on the exchange.

4.2 Data and methodology

Many studies have been published on the abnormal performance of momentum strategies around the world as discussed in *section 3, Momentum strategies*. Some of these included the Danish stock market but always as part of a greater sample. Therefore it is interesting to make an empirical test on the Danish stock market to see if price momentum exists.

The methodology applied in the empirical study of the Danish stock market will, to the extend that it is possible, be a replication of the methodology used in the benchmark study of Jegadeesh and Titman (1993). The reason for this is that most studies have followed this methodology, which makes it easier to compare the results with similar studies. The reduced size of the firm sample, the aim and scope of this thesis and other factors can however make the methodology used in this study deviate from the benchmark study. These deviating methodology choices will be made clear and rationalized in the particular part of the assignment where a different method is applied. I will for example in some places use new methods including how illiquid stocks are screened from the sample and how a reasonable sample size is maintained.

The data used in the empirical analysis is obtained from the program Datastream Advance (version 4.0) produced by Thomson. Datastream is one of the world's largest and most respected financial statistical databases, and has been applied in several of the significant momentum studies including Chan et al. (2000), Swinkels (2002) and Griffin et al. (2003). The stock prices have been adjusted for capital restructurings, stock splits and dividend payouts. The sample consists of 79 common stocks that have been listed on the Copenhagen Stock Exchange at some point in the period 1 May 1988 – 1 March 2008. The sample data consist of individual monthly prices obtained at the first trading day of each month and the prices are quoted in Danish currency DKK. Price information is not available for all the stocks in the entire period as some stocks are listed on the Copenhagen Stock Exchange later than the start of the period and some stocks are delisted before the end of the period. The cut off date at 1/5 1988 has been chosen because many of the large Danish firms went public and got listed on the Copenhagen Stock Exchange in that particular month (going back only one month to 1/4 1988 would have reduced the sample by 10 stocks).

Another important reason is that Datastream does not record detailed dividend payments before 1988, which would have complicated the calculation of exact returns. I have arbitrarily selected a criterion that dictates that there at any given month should be at least 35 stocks that can be included in the empirical analysis and divided into portfolios based on past 6 month returns. This criterion ensures a sample of reasonable size so that end results are less likely to be driven by empirical anomalies and more likely to be representative of the Danish stock market as a whole. In *table 4.1* below the companies in the sample are listed and categorized by industry. The industry categorization applied is the same as the OMX exchange make use of (www.omx.dk). Companies in the financial sector represent the largest sector in the sample and constitute 34 percent of the stock sample, while industry companies as the second largest sector represent 28 percent of the stock sample. The remaining large sectors are: health care companies (12 percent), consumer staple companies (9 percent) and consumer discretionary companies (8 percent). If we measure the percentage the different sectors represent as measured by market cap, industry is the largest sector in the Danish stock market, mainly driven by the large Mærsk ‘A’ and Mærsk ‘B’ stocks.

In the price momentum strategy equal weights will be applied, which indicates that the sample will be more weighted towards financial companies than industry companies. This is an important observation to bear in mind when commenting on the outcome of the empirical study, as the results then could be overly driven by price characteristics of financial companies.

Table 4.1 Stock sample

Industry:	**Financial:**	**Health Care:**
Mærsk ‘A’	Danske Bank	Novo Nordisk
Mærsk ‘B’	Topdanmark	Genmab
Vestas Wind Systems	Sydbank	William Demant
FLSmidth & Company ’B’	Trygvesta	Lundbeck
D/S Norden	Nordea Bank	GN Store Nord
DSV ‘B’	Jyske Bank	Coloplast ’B’
NKT	OMX	Alk-Abello
Rockwool ‘A’	Alm. Brand	Neurosearch
Rockwool ’B’	Spar Nord Bank	Bavarian Nordic
G4S	EBH Bank	
SAS	Sparekassen Himmerland	**Consumer Stables:**
Københavns Lufthavne	Jeudan	Carlsberg ’A’
DFDS	Ringkjøbing Landbobank	Carlsberg ’B’
Schouw & Co.	Sjælsø Gruppen	Danisco
Mols-Linien	Roskilde Bank	Østasiatiske Kompagni
Solar ‘B’	Fiona Bank	Royal Unibrew
	Forstædernes Bank	United International Enterprises
Dead stocks:	Amagerbanken	
Group 4 Falck	Nordicom	Dead stocks:
Vest-Wood	Capinordic	Hatting Bageri
MicroMatic	Sparbank	
ISS	Nørresundby Bank	**Consumer Discretionary:**
J. Lauritzen	TK Development	Bang & Olufsen
SAS Danmark	Vestjysk Bank	IC Companys
		Parken Sport & Entertainment
Telecommunication:	Dead stocks:	Tivoli ‘B’
TDC	Codan	Rella Holding
	Keops	Royal Scandinavia
Information Technology :	Tryg Baltica Forsikring	
Simcorp		**Supply:**
	Materials:	Greentech Energy Systems
Energy:	Novozymes	Biomar Holding
D/S Torm	Auriga Industries	

Following the Jeegadesh and Titman (1999) methodology stocks have been chosen on the basis of descending market capitalization, so that the 79 stocks in the sample represent as large a percentage as possible of the total current market capitalization of the Copenhagen Stock Exchange. This is done to ensure that the empirical results are not driven by small and illiquid stocks and also to avoid the influence of bid-ask bounce effect on the results. Stocks with less than 12 months of price data are omitted for the same reason. 11 dead stocks (stocks which have been delisted during the sample period) are included in the sample in order to avoid survivorship bias.

The dead stocks are also chosen on the basis of descending market capitalization and other general considerations such as the representative value of the stock. The avoidance of survivorship bias is important as it could distort the results of the empirical analysis. Stocks are continuously delisted on stock exchanges, either due to bankruptcy, mergers and acquisition activity or strategic business reasons. It is an important aspect of investing in equities and the inclusion of dead stocks in the sample will represent this aspect and thereby alleviate the survivorship bias. I follow in part some of the Griffin et al. (2003) methodology and screen the Datastream Advance data. This is done to eliminate the error of data biases and correct for possible errors in the Datastream data. Mutual fund stocks, investment certificates stocks or stocks, which price is directly affected by the performance of other stocks have been excluded from the data sample. I have not chosen to only pick one class of stocks in cases were a stock have multiple classes, as many previous studies have done. This is has been done mainly because class B stocks are considered more liquid than class A stocks.

The reason why I include both classes of stocks is that I put more emphasis on including large market capitalization stocks in the sample, and that the difference in returns between two classes of stocks is large enough to affect the end results. I use an alternative method to exclude illiquid stocks from the sample. Illiquid stocks will be defined as stocks, which have the same trading price in six consecutive months, and these stocks will be excluded from the sample. The reason for this is to ensure that all stocks in the sample are traded regularly. That the stocks in the sample are liquid is also important if the price momentum strategy were to be implemented as a trading strategy by institutional investors or market markers, which have to invest large amounts of money without influencing the price significantly. Illiquidity issues are more important to be aware of on small capital markets, and as described above in *section 4.1* the Danish stock market is relatively small with a small market value and overall trading volume.

4.3 Portfolio formation

The portfolio formation process follows the same methodology as Jeegadesh and Titman (1993). Each month stocks in the sample are ranked from highest to lowest based on past returns. This ranking period is also called the formation period. After stocks are ranked from highest to lowest based on their past return, the stocks are divided into different portfolios, so that the stocks with the highest past returns are bundled in one portfolio, the stocks with the second-highest past returns are bundled in another portfolio etc. After the formation period follows the holding period. In the holding period the different portfolios are held for a given period of time. The holding period returns of the different portfolios will reveal if the stocks that have performed well in the past period will still continue to perform well in the future period. If this link can be established it will indicate the existence of price momentum in the Danish stock market.

In this empirical study most emphasis will be put on a benchmark strategy that has a formation period of 6 months and a holding period of 6 months. The reason why I have chosen to study this particular strategy is that most price momentum research have focused on this strategy, and for the same reason a lot of research results regarding this strategy are readily available. This will enable me to put the results of this empirical study into a broader context, thus ensuring a broad statistical and empirical base to compare the results with. As explained above each month during the formation period the sample will be divided into different portfolios. In Jeegadesh and Titman (1993) they divide their sample into 10 different portfolios, but their stock sample size is significant larger than the sample size of my empirical study. Therefore due to the sample size of 79 stocks, I have chosen to divide the sample into 5 different portfolios in my benchmark strategy. This entails that portfolio 1 represent the 20 percent of the sample with the highest 6-month returns, portfolio 2 represent the 20 percent of the sample with the second highest 6-month returns etc. Portfolio 1 is also called the “winner” portfolio and portfolio 5 is also called the “loser” portfolio.

In order to control the results and increase the power of the test a robustness check is made. Although most emphasis will be put on the benchmark strategy with a 6-month formation period and a 6-month holding period, a robustness check will ensure that the results of the benchmark strategy are not a statistical anomaly. Therefore the benchmark strategy will be compared to a strategy with a 12-month formation period and a 12-month holding period. The methodology used for this strategy is identical to the methodology used in the benchmark strategy, which will make the results directly comparable and also help identify the most successful price momentum strategy. Furthermore the benchmark strategy, which divides the sample into 5 portfolios, will be compared to strategies, which divide the sample into 10 and 3 portfolios instead of 5. This different portfolio composition will help indicate in which decile, quintile or third the momentum driven stocks are most prevalent. Now we have two different lengths of formation and holding period and three different portfolio compositions, which gives us a total of 6 different strategies. This should be sufficient as to test the robustness of the benchmark strategy.

In between the holding period and the formation period a skipping period can be inserted in order to create a lag that ensures that stock prices are not driven by bid-ask bounce pressure. This was done in Jeegadesh and Titman (1993) and other studies that replicated the methodology of this study. Below in *table 4.2* are reported the results of the momentum strategies of Jeegadesh and Titman (1993). In the left box are the results that use no skipping period between the formation period and holding period and in the middle box are the results that use a 1-week skipping period between the formation and holding period. In the right box are reported the difference in returns between the strategies that use no skipping period and the strategies, which do use a 1-week skipping period. The top number indicates the monthly return of the "winner" portfolio in each strategy, while the bottom number (in italics) is the monthly return of the "loser" portfolio (H: holding period, F: formation period).

If we look at the difference between the 6-month formation and holding period strategy (which is our benchmark strategy) with and without the use of a skipping period, we see that there is a marginal difference of 0.04 percent for the "winner" portfolios and 0.15 percent for the "loser" portfolios. If we look at the strategy with a 12-month formation and holding period (which is our robustness check strategy) we see that the difference in returns 0 percent. These differences in returns are found to be insignificant and the resulting effects of bid-ask spread, price pressure and lagged reaction on the return of such strategies are therefore also insignificant. For this reason the empirical study will not make use of a skipping period between the formation period and holding period. The benchmark strategy will therefore be a 6-0-6 (the first number represents the monthly length of the formation period, the second number represents the monthly length of the skipping period, while the third number represents the monthly length of the holding period) and the robustness check strategy a 12-0-12 strategy.

Table 4.2 Differences between returns with and without lag

Without lag

F \ H	3	6	9	12
3	.014 *.0032*	.0149 *.0058*	.0152 *.0061*	.0156 *.0069*
6	.0171 *.0084*	.0174 *.0095*	.0174 *.0102*	.0166 *.0086*
9	.0186 *.0109*	.0186 *.0121*	.0176 *.0105*	.0164 *.0082*
12	.0192 *.0131*	.0179 *.0114*	.0168 *.0093*	.0155 *.0068*

With lag

F \ H	3	6	9	12
3	.0156 *.0073*	.0158 *.0078*	.0158 *.0074*	.0160 *.0077*
6	.0179 *.0114*	.0178 *.0110*	.0175 *.0108*	.0166 *.0090*
9	.0186 *.0109*	.0186 *.0121*	.0176 *.0105*	.0164 *.0082*
12	.0192 *.0131*	.0179 *.0114*	.0168 *.0093*	.0155 *.0068*

Difference

F \ H	3	6	9	12
3	.0016 *.0041*	.0009 *.0020*	.0006 *.0013*	.0004 *.0008*
6	.0008 *.0030*	.0004 *.0015*	.0001 *.0006*	.0000 *.0004*
9	.0000 *.0000*	.0000 *.0000*	.0000 *.0000*	.0000 *.0000*
12	.0000 *.0000*	.0000 *.0000*	.0000 *.0000*	.0000 *.0000*

As explained above stocks are ranked each month based on returns, which are calculated for the 79 stocks in the entire sample period. The stock returns are calculated on the basis of the stock prices, quoted in the local Danish currency, DKK. Past 6-month returns are calculated as follows: $P_j/P_{j}\text{-}_6$, where Pj= the price of the stock at the start of a given month J and $P_{j}\text{-}_6$= the price at the start of the month 6 months prior to month J. Past 12-month returns are calculated in the same way: $P_j/P_{j}\text{-}_{12}$, where Pj= the price of the stock at the start of a given month J and $P_{j}\text{-}_{12}$= the price at the start of the month 12 months prior to month J. If the stock has not been listed and therefore do not have a quotable price dating back 6 or 12 months, no return will calculated in that month for that particular stock. Therefore the number of returns that can be calculated in each month will vary during the period as more stocks get listed or a delisted. If a stock is delisted after it is included in a portfolio but before the end of the holding period, it's return is replaced with the average return of all the stocks in the sample in that given period. This is found to be the most suitable return as it implies that the position in the delisted stock is shifted to a position in the market portfolio in that given period.

When the individual returns has been calculated, the stocks are then divided into portfolios based on these returns, and the portfolio mean return is found for each portfolio. This mean return is calculated as a simple mean and therefore the arithmetic and the geometric mean do not diverge. But when the mean of portfolio mean returns in the entire 227-month period has to be calculated, the arithmetic mean will be higher than the geometric mean. In Jegadeesh and Titman (1993) the arithmetic mean was applied, while in their 1999 study they applied the geometric mean instead.

The arithmetic mean has an upward bias, while the geometric mean has a downward bias due to the inability of the geometric mean to accurately account for negative numbers. This empirical study will make use of both the geometric mean as well as the arithmetic mean to ensure that the results are not driven by the way means are calculated. Nonetheless geometric means a more suited for time series data with an assumed underlying trend. Stocks are assumed to have an underlying trend as they are expected to show a positive growth rate each year. A reasonable accurate estimation of the arithmetic mean can be calculated as the squared value of the geometric mean plus the variance of the underlying variable (in this case stock returns). Hence the arithmetic mean equals only the geometric mean when there is no variance in the time series data. Stocks are risky assets and risky assets exhibit variance, therefore geometric means should be more reliable and conservative when applied to time-series data than the arithmetic mean.

Overlapping periods are used in the empirical study as they were in the study of Jegadeesh and Titman (1993). This is done in order to increase the power of the test. The methodology of overlapping portfolios is that instead of waiting 6 months before another portfolio is constructed, a portfolio is constructed each month. This means that in case of the 6-0-6 benchmark strategy 227 portfolios can be constructed instead of 37, and in the 12-0-12 strategy 227 portfolios can be constructed as opposed to a mere 18. This increases the statistical significance of the results.

Using overlapping periods entails that each month a new portfolio is constructed on the basis of the stocks past 6-month returns (12-month return), included in the trading portfolio and held for 6 (12) months. Therefore the trading portfolio at all times consists of 6 (12) different portfolios formed in each of the 6 (12) months leading up to T_0. Consequently a portfolio is realized each month as it's holding period expires and 1/6 (1/12) of the trading portfolio is revised and a new portfolio is included instead of the realized portfolio. One downside of using overlapping portfolios instead of non-overlapping portfolios is that overlapping can create econometric problems, as the return of the portfolio is going to exhibit positive correlation, which could influence the result, but the statistical significance that the overlapping portfolio method adds has been found to outweigh this issue.

A t-test will be calculated for each mean return to ensure that the mean returns of the individual portfolios are statistically different from the sample mean and thereby can be said to be statistical significant. For the t-test the Microsoft Excel independent two sample (with unequal variance and unequal sample size) for means-test is applied. The formula is as follows:

$$T = \frac{X - Y}{\sqrt{\frac{s_1^2}{m} + \frac{s_2^2}{n}}}$$

X and Y are the mean sample averages. S^2 is the standard deviation of the sample and m and n are the number of observations. The resulting t-score is compared to certain critical values of a student t distribution table to determine the t-score's statistical significance. Three t-scores will be reported. These are comparisons of the means of the "winner" portfolio, the "loser" portfolio and the long-short zero-cost strategy to the mean of the equal weighted index.

An equal weighting of the different stocks and portfolios will be applied as in Jeegadesh and Titman (1993). Therefore each portfolio is weighted equally and no weighted average of returns needs to be calculated as the differences in market capitalization between different portfolios is ignored.

4.4 Long-short zero-cost trading strategy

The best way of measuring the combined momentum effect of the "winner" and the "loser" portfolio is to measure the return of a trading strategy that consistent takes a long position in the "winner" portfolio and sells short the "loser" portfolio. If the "winner" portfolio continues to earn high returns and the "loser" portfolio continues to underperform this strategy will earn a high return.

Such a trading strategy is called a long-short zero-cost strategy, which means that no outlay of money is needed as the proceeds of the short sales are used to fund the long purchases, hence the short selling is financing the long position. In the stock market this is in general not an implementable strategy, as there would exist a natural lag between short selling and taking a long position with the proceeds of the same short selling. This is because the investor who sells short only gets the money from the sale when the investor has delivered the equities to the buyer, so when the seller goes short in the beginning of the investment period he or she will not receive the money before the end of the investment period. But in this empirical study the return of such a strategy will still provide us with a good measure of the momentum effect, and again it is important for the empirical study to be comparable to the existing literature on momentum, which has made great use of the long-short zero-cost strategy.

4.5 Data-snooping issues

Whenever you search for statistical significant links in historical data sets, there is a risk that the process used to identify these links can potentially generate misguiding results. The problem is most prevalent when you use a set of historical data to develop a model, and then test the model on the same set of historical data. This process captures all the biases inherent in that particular data set and the model will therefore only work on data sets with these biased properties, and even a statistical correct performance measure of the model could give evidence to believe that a fundamental relationship has been detected, although contrary to the reality. Sullivan et al. (1999) call this issue for the data-snooping issue. Data-snooping and the more known term data mining are related issues.

Data-snooping refers to process in which you gradually filter a large number of more or less related models on a given historical data sample until you find the model that has performed empirically superior. If the model is then evaluated on the same data sample, the model will seem to have predictive power and pass all the standard statistical tests of robustness, even though the observed links are purely accidental. Data-snooping issues are very relevant when examining the performance of different momentum trading strategies. If you examine the historical performance of a large number of different momentum strategies on a large data sample, there still is a risk that one the trading strategies will perform on a superior level due to randomness, which can result in faulty conclusion about this particular trading strategy. If instead only a small number of trading strategies are examined you still run the risk of data-snooping as it cannot be rejected that most of the momentum trading strategies that are widely applied today and therefore also are the subject of the most studies, is the result of a gradual filtering of different trading strategies over time.

The consequence of this gradual filtering could be that momentum strategies that historically have performed poorly or on par with the market has been filtered out, and only those momentum strategies, which have a trading system that match the development in the historical market data has survived the test of time. Investors will then view the historical profitability of these momentum strategies as evidence of their universal profitability, and ignore the fact that the profitability of the strategies could have happened by chance and that the probability that they will continue to be profitable is small.

The issue of data-snooping is therefore also a problem arising out of indeliberate coincidental actions of different researchers over time, as it is a result of deliberate manipulation of data. This makes the issue more difficult to identify and take precautions against in a standardized statistical test in order for the problem to be alleviated and the data sample corrected.

Parmler and Gonzalez (2007) delves into the problem of data-snooping in price momentum studies. They use two different data samples in their study. One data sample is comprised by NYSE, AMEX and Nasdaq stocks in the CRSP database in the period 1963-2004 and the other data sample consist of all stocks listed on the Stockholm Stock Exchange over the period 1979-2003. They follow the procedures of earlier studies and use these data samples to compare the profitability of a momentum strategy with a benchmark model strategy after the effects of data-snooping have been controlled for. Although Parmler and Gonzalez find strong evidence of momentum effects in their US stock sample and also find significant profitability in momentum strategies that are based on individual stock momentum in their Swedish stock sample, they conclude that data-snooping bias can severely affect the results and conclusions of a price momentum study.

They argue that this conclusion is backed by the fact that momentum is only found to be significant in the first subperiod (1965-1983) of the US data sample and no or only weak momentum effects are found in the Swedish stock sample, when momentum strategies that divide the stocks into portfolios on the basis of industry, size or book-to-market classifications are examined. They do not reach this conclusion by comparing momentum profitability before and after they control for data-snooping effects, which would be a more robust check of data-snooping effects.

In this study an already developed model trading strategy by Jegadeesh and Titman (1993) will be tested on a data set, which it has never been tested upon before. This enhance the probability that the before mentioned data snooping issue can be avoided and ensures that the tested momentum strategy will be either reinforced because of it's validity on a new data set, or can be partly rejected with precautions of the possibility errors in data or methodology in this particular study. The methodology of Jegadeesh and Titman (1993) has been applied in many subsequent studies where some studies have followed the methodology meticulously and other studies have only replicated some of the methodology. In this study the methodology of Jegadeesh and Titman (1993) will be followed in detail wherever possible, so as few variables as possible is change, which will help increase the power of test.

4.6 The empirical results

In this section the empirical results will be presented. Most emphasis will be placed on the 6-0-6 strategy that divides the stocks into 5 portfolios, but if the 12-0-12 strategy results and/or the strategies where the sample is divided into 10 or 3 portfolios deviate significantly from the 6-0-6, 5 portfolio strategy this will be commented on. Both geometric and arithmetic means will be reported for reasons explained in *section 4.3, Portfolio formation*.

4.6.1 Returns

Table 4.3 presents average monthly holding period returns for the 6-0-6 strategy, while *table 4.4* presents the average monthly returns for the 12-0-12 strategy. The "winner" portfolio (always portfolio 1) comprises stocks with the largest formation period returns and portfolio 5, 10 or 3 (depending on whether we divide the entire sample into 5, 10 or 3 portfolios) or the "loser" portfolio comprises stocks with lowest formation period returns. The difference between the "winner" portfolio and the "loser" portfolio is our long-short zero-cost trading strategy. The Equal Weighted Index (EWI) is the average of the portfolios and is a measure of the average return of the whole sample. Geometric means are reported with arithmetic means in the parenthesis.

The results in *table 4.3* indicate a strong link between momentum in stocks when ranked during the formation period and the subsequent returns of these stocks, whether the "winner" and "loser" portfolio each comprises 20 percent, 10 percent or 30 percent (same as 5, 10 or 3 portfolios) of the total sample. The difference between the "winner" portfolio and the "loser" portfolio when we divide the sample into 5 portfolios (which is the same as a long position in portfolio 1 and a short position in portfolio 5) is 1.26 percent (1.28 percent). The monthly return of the long-short zero-cost strategy is therefore 0.15 percent (0.05 percent) higher (lower) than the Equal Weighted Index return, which is 1.11 percent (1.33 percent). But a long position in the "winner" portfolio would have yielded an impressive monthly return of 1.96 percent (2.25 percent), which is 0.85 percent (0.92 percent) in excess of the Equal Weighted Index.

The t-statistic for the “winner” portfolio makes the result statistical significant at a 99 percent confidence level, whereas the t-statistic for the “loser” portfolio is statistical significant at a 95 percent confidence level and the long-short zero-cost strategy is not statistical significant.

Table 4.3 6-0-6 portfolio returns

	5 portfolios	10 portfolios	3 portfolios
Portfolio 1	**1.96 % (2.25 %)**	**2.09 % (2.44 %)**	**1.77 % (2.03 %)**
Portfolio 2	1.31 % (1.49 %)	1.83 % (2.05 %)	0.93 % (1.05 %)
Portfolio 3	0.87 % (1.03 %)	1.40 % (1.60 %)	**0.69 % (0.95 %)**
Portfolio 4	0.71 % (0.91 %)	1.22 % (1.38 %)	
Portfolio 5	**0.70 % (0.97 %)**	0.95 % (1.07 %)	
Portfolio 6		0.79 % (0.99 %)	
Portfolio 7		0.74 % (0.92 %)	
Portfolio 8		0.68 % (0.90 %)	
Portfolio 9		0.69 % (0.98 %)	
Portfolio 10		**0.71 % (0.96 %)**	
“winner” – “loser”	1.26 % (1.28 %)	1.38 % (1.48 %)	1.08 % (1.08 %)
EWI	1.11 % (1.33 %)	1.11 % (1.33 %)	1.11 % (1.33 %)
T-statistics: W, L, W-L	4.59, 2.2, 0.86		

If we compare strategies that use different portfolio composition we see that the strategy that divides the sample into 10 portfolios is the most profitable and the strategy which uses only 3 portfolios is the least profitable. The long-short zero-cost trading strategy yields a monthly return of 1.38 percent for the 10 portfolio strategy, 1.26 percent for the 5 portfolio strategy and 1.08 percent for the 3 portfolio strategy. The results are not significantly different if we look at arithmetic means, but it should be noted that the long-short zero-cost 10 portfolio strategy outperforms the Equal Weighted Index when geometric as well as arithmetic means are applied, the long-short zero-cost 5 portfolio strategy only outperforms the Equal Weighted Index using the geometric mean while the long-short zero-cost 3 portfolio strategy underperform the Equal Weighted Index in each case.

It is also interesting to observe that while the returns of the "loser" portfolio in the 5,10 and 3 portfolio strategies are almost identical (0.70 percent, 0.71 percent and 0.69 percent (0.97 percent, 0.96 percent and 0.95 percent)) the "winner" portfolios have significantly different returns (1.96 percent, 2.09 percent and 1.77 percent (2.25 percent, 2.44 percent and 2.03 percent). Looking at portfolio 4 in the 5 portfolio strategy or portfolios 6-9 in the 10 portfolio strategy we also see that these portfolios have almost identical returns as the "loser portfolio". This implies that for example in the 5 portfolio strategy the "loser" portfolio contributes as much to the overall momentum effect in the 6-0-6 strategy as portfolio 4 would have done.

In *table 4.4* we see the results of the 12-0-12 strategy with the same three different portfolio division structures. This strategy does not indicate a strong link between momentum portfolios and subsequent returns. The "winner" portfolio is still the overall most profitable portfolio, but interestingly it is only marginally more profitable than the "loser" portfolio. The resulting return of the long short zero cost strategy is very close to 0 percent and the equal weighted index outperforms the long-short zero-cost strategy with 1.01 percent in case of the 5 portfolio strategy when applying geometric means. The long-short zero-cost strategy is even less profitable when using arithmetic means. In this case a long position in either the "winner" portfolio or "loser" portfolio would have significantly outperformed the Equal Weighted Index. This could be an indication of the momentum effect still lingering in the "winner portfolio" albeit considerably weakened when compared to the 6-0-6 strategy. And in case of the "loser" portfolio it could indicate the long-term mean reversal in returns, which have been documented in De Bondt and Thaler (1985, 1987). If the observation of a "winner" portfolio still exhibiting momentum in the 12-0-12 strategy, while the "loser" portfolio is also showing significant returns it is very likely due to skewed momentum characteristics of the "winner" and "loser" portfolio. The resulting mismatch between the returns in the "loser" and "winner" portfolio conveys information, which at face value shows that the momentum effect is more prevalent and more longer-lived in the "winner" portfolio than in the "loser" portfolio. Additional empirical studies, which are beyond the scope and aim of this assignment needs to be conducted in order for this observation to be more robust.

Only the t-statistic for the long-short zero-cost strategy is statistical significant.

Table 4.4 12-0-12 portfolio returns

	5 portfolios	**10 portfolios**	**3 portfolios**
Portfolio 1	**1.52 % (1.86 %)**	**1.65 % (1.95 %)**	**1.42 % (1.70 %)**
Portfolio 2	1.16 % (1.38 %)	1.39 % (1.77 %)	1.08 % (1.27 %)
Portfolio 3	1.19 % (1.38 %)	1.21 % (1.39 %)	**1.21 % (1.64 %)**
Portfolio 4	0.93 % (1.14 %)	1.11 % (1.37 %)	
Portfolio 5	**1.31 % (1.83 %)**	1.15 % (1.39 %)	
Portfolio 6		1.23 % (1.35 %)	
Portfolio 7		0.84 % (0.92 %)	
Portfolio 8		1.02 % (1.26 %)	
Portfolio 9		1.12 % (1.75 %)	
Portfolio 10		**1.50 % (1.91 %)**	
"winner" – "loser"	0.21 % (0.03 %)	0.15 % (0.04 %)	0.21 % (0.06 %)
EWI	1.22 % (1.52 %)	1.22 % (1.52 %)	1.22 % (1.52 %)
T-statistics: W, L, W-L	1.36, 0.39, 5.06		

4.6.2 Comparability with other studies

In *table 4.5* the 6-0-6 results are compared to the benchmark studies of Jeegadesh and Titman (1993, 2001). The results are similar to these two price momentum studies as all three studies report strong momentum profits. The "winner" portfolio appears to be driven by momentum in the holding period resulting in high returns that outperform the average return of the sample (EWI). The "loser" portfolio is outperformed by the EWI and also indicates that past losers also on average have low future returns.

If we measure the difference between the "winner" and "loser" portfolio and the EWI in Nørregård (2008) we see that the "winner" portfolio outperforms the EWI with 0.85 percent (0.92 percent) and the "loser" underperforms the EWI with 0.41 percent (0.36 percent). This results indicates that the “winner” portfolio contributes around 2/3 of the momentum effect and the “loser portfolio” contributes the remaining 1/3 when the EWI is used as the benchmark. This reinforces the finding from earlier that the momentum effect in the “winner” portfolio seems to be more prevalent and stronger than in the “loser” portfolio. In Jeegadesh and Titman (1993) the “winner” portfolio outperforms the EWI with 0.43 percent while the “loser” portfolio underperforms the EWI with 0.52 percent and in Jeegadesh and Titman (2001) the “winner” and “loser” portfolio also contributes around half of the momentum effect each.

Table 4.5 Comparison of portfolio returns

	“winner”	**“loser”**	**“winner-loser”**	**EWI**
Nørregård (2008)	**1.96 %** **(2.25 %)**	**0.70 %** **(0.97 %)**	**1.26 %** **(1.28 %)**	**1.11 %** **(1.33 %)**
J&T (1993)	1.74 %	0.79 %	0.95 %	1.31 %
J&T (2001)	1.65 %	0.42 %	1.23 %	1.09 %

4.6.3 Risk-adjusted returns

When we compare the EWI or the “sample market” with the long-short zero-cost strategy we are simply comparing returns. But this simple comparison of returns fails to take into account the difference in risk of each portfolio. If we also want to evaluate the different portfolio returns by taking risk into account, we need to adjust the returns for risk. An acknowledged way of measuring risk-adjusted returns is by calculating the Sharpe ratio.

The Sharpe ratio is calculated by dividing the excess of a given asset’s return over a risk-free return with the standard deviation of an asset. We use 4 percent as the historical average risk-free rate. The ratio can then be compared to other ratios and the higher the ratio is the more return per unit of “risk” the asset produces. This is a useful way evaluating different strategies and in *table 4.6* we see the different Sharpe ratios of the “winner” portfolio, the “loser” portfolio, the long-short zero-cost trading strategy and the EWI (Monthly returns and standard deviations has been annualized).

Table 4.6 Sharpe ratios

	Annualized Sharpe ratios	**Annualized Standard deviation**
"Winner" portfolio	0.75 (0.89)	0.28
"Loser" portfolio	0.19 (0.31)	0.26
Long-short zero-cost strategy	0.52 (0.54)	0.22
EWI	0.42 (0.54)	0.23

As we can see the "winner" portfolio is the best performing portfolio whether you apply the geometric or arithmetic mean. It has a Sharpe ratio, which is 3-4 times higher than the "loser" portfolio and almost twice as high as the EWI. The risk as measured by the annualized standard deviation is highest the "winner" portfolio and lowest for the EWI, but the spread in risk is very limited. This explains the high Sharpe ratio of the "winner" portfolio, as the risk of the portfolio is almost identical to the risk of the "loser portfolio and the EWI but the return is significantly higher. The long-short zero-cost strategy is the second-best performing portfolio with a Sharpe ratio that is 2-2.5 times higher than the "loser" portfolio but only 0-20 percent higher than the EWI. The reason why the long-short zero-cost strategy is better than the EWI is due to a higher monthly return of 0.15 percent (1.26 percent as compared to 1.11 percent) and a marginally lower combined standard deviation of a long position in the "winner" portfolio and a short position in the "loser" portfolio (0.22 as compared to 0.23).

4.7 Summary

This section was dedicated to the empirical study of price momentum strategies on the Danish stock market in the period 1988-2008. 79 Danish stocks listed in the period on the Copenhagen Stock Exchange were included in the data sample. The stocks were ranked on a monthly basis according to their past 6-month returns (12-month returns) and divided into portfolios. A long-short zero cost trading strategy, which took a long position in the portfolio with the highest return and a short position in the portfolio with lowest return was applied during the period.

The results showed that in the 6-0-6 scenario the long-short zero cost trading momentum strategy was more profitable than the Equal Weighted Index (but only when geometric means are applied), and that the profitability becomes marginally more evident when adjusted for risk through the Sharpe ratio. Therefore this particular momentum strategy did outperform the Equal Weighted Index, but not in a superior manner. But the results also indicated that if a long position had been taken in the winner portfolio only, it would have outperformed the Equal Weighted Index far more than the traditional long-short zero-cost momentum strategy, also after adjusting for risk. The robustness check with the 12-0-12 strategy showed that momentum profits faded out when the formation period and holding period was extended to 12 months instead of 6 months. With this strategy the Equal Weighted Index is far more profitable than the long-short zero-cost strategy. But interestingly a long position in both the “winner” and “loser” portfolio would have outperformed the Equal Weighted Index indicating that the “winner” portfolio is still driven by momentum and the “loser” portfolio is showing long-term mean reverting characteristics.

The results are similar to the benchmark study of Jeegadesh and Titman (1993) due to the documentation of strong momentum profits but the results are different in the different characteristics of the “winner” and “loser” portfolio.

5. Conclusion

The aim of this thesis was to investigate the occurrence and properties of intermediate-term price momentum in the stock market. Former theoretical and empirical contributions in the field of behavioral finance as well as traditional finance was used to illuminate the plausible theoretical causes of price momentum as well as the empirical characteristics and properties of this pricing anomaly.

Basic traditional finance theory was compared to behavioral finance theory and the differences in assumptions about investor rationality and behaviour and the resulting difference in aggregate market theory was described in the theoretical section. These theoretical discrepancies paired with the substantial empirical studies documenting the existence of intermediate-term price momentum in various stock markets around the world, identified a gap between traditional finance theories and observed stock return behaviour.

This gap became even more evident due to the explorative empirical study on price momentum that was conducted on the Danish stock market. An intermediate-term momentum strategy was applied on 20 years of stock market data concerning 79 stocks listed on the Copenhagen Stock Exchange. The results showed significant profitability of the applied long short zero-cost momentum strategy, which is in accordance with the findings of the benchmark study of Jeegadesh and Titman (1993). This entails that the momentum strategy would have outperformed a long position in all the 79 stocks in the 20-year period, although the outperformance is not very superior. Interestingly the empirical analysis indicated that it was the “winner” portfolio that was the main contributor to the overall momentum effect. The profitability of a strategy that would have taken a long position in the “winner” portfolio would have outperformed a long-short zero-cost strategy with a long position in the “winner” portfolio and a short position in the “loser” portfolio. The profitability of the “winner” portfolio is, albeit lessened, still superior to the long-short zero-cost momentum strategy after controlling for differences in risk.

If the same long-short zero-cost momentum strategy was applied but the formation and holding period extended from 6 to 12 months the returns became different. The “winner” portfolio was still the portfolio with the highest return and still exhibiting momentum although considerably lessened from the “winner portfolio” in the 6-0-6 strategy. But the “loser” portfolio showed signs of return reversal as the return of the “loser” portfolio was the second-highest and only slightly lower than the return of the “winner” portfolio.

These empirical findings that bring evidence to the existence of price momentum in equity prices on the Copenhagen Stock Exchange are strong counterarguments to the Efficient Market Hypothesis, CAPM and other traditional finance theories and models. The underlying foundation of the Efficient Market Hypothesis and the CAPM is that rational agents solely base their investment decisions on the available information about fundamental value drivers and correctly price this information into stock prices and that any irregularities on the market will quickly be corrected. But the existence of price momentum over a 20-year period in the Danish stock market gives fuel to the argument that stock prices are also comprised of some elements of behavioural stock pricing. Although it seems plausible that certain behavioural investor tendencies such as conservatism and the disposition effect causes market underreaction which then causes price momentum, empirical proof of such a link has proven hard to produce. But in the meantime momentum in intermediate term should no longer be seen as a market anomaly and instead be reckoned as a main market factor that should be taken account of and incorporated into every trading strategy.

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