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Achieving higher returns with Piotroski's F_Score model

An empirical study on the Swedish stock market

This thesis evaluates the success of a fundamental investing strategy on the Swedish stock market between 2004 and 2016. The main purpose is to examine if the F_Score system developed by Piotroski (2000) could be used to identify winners and losers during aforementioned time frame. A lot of research has previously been conducted on the topic of fundamental investing and some focusing on F_Score. This work should be seen as a contribution to the existing research. It contributes by examining a different region during a different time and by changing some of the system's characteristics. The collected data is statistically tested using a t-test with varying levels of significance. The results of the thesis imply that a investor could increase his or her risk-adjusted returns by using Piotroski's system to separate good firms from bad. Moreover, it implies that the investor could garner a greater risk-adjusted return than the market in general, which contradicts the efficient market hypothesis.

Keywords: F_Score, Fundamental investing, Value investing, Abnormal returns, Market efficiency

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Acronyms

Amex	American Stock Exchange
B/M	Book-to-Market
CAPM	Capital Asset Pricing Model
CFO	Cash Flow from Operations
D/E	Debt divided by Equity
DS	Thomson Reuters Datastream
EMH	Efficient Market Hypothesis
HML	High-Minus-Low
IV	Intrinsic Value
NYSE	New York Stock Exchange
P/E	Price divided by Earnings
SMB	Small-Minus-Big

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1. Introduction

The intent of the thesis is to asses Piotroski's (2000) F_Score investment strategy, but assessing it on the Swedish stock market instead of the U.S. Furthermore, to evaluate the strategy, we conduct the study on a more recent period, 2004-2016, compared to Piotroski's period of 1976-1996. The thesis should be seen as a contribution to existing body of research regarding value investing and fundamental investing in general, and F_Score more specifically, whilst contributing on the topic if markets are efficient.

Eugene Fama (1970) argues that stock markets exhibit three forms of efficiency, each bearing moderately different characteristics than the other. One is referred to as the semi-strong efficient market according to Fama's (1970) efficient market hypothesis (EMH). If the examined stock market bears the characteristics of a semi-strong efficient market, the prices would promptly adjust to reflect the announcement of new value-relevant information, which may regard systemic or firm-specific information, or both. The prices reflected in a semi-strong market incorporates all publicly available data excluding insider information. Furthermore, according to Sharpe (1964), there are no arbitrage opportunities in the stock market, and if investors aim to increase their returns, they must increase their level of risk.

However, since the inception of the EMH, there have been a mounting number of observations by researchers contradicting the EMH, for instance, the post-earnings announcement drift. Such anomalies are an indication of brief mispricing in a stock's price which diverted from its intrinsic value (IV). The existence of anomalies has resulted in several researchers and investors attempting to construct investment strategies to generate abnormal returns without increasing their level of risk (Bodie, Kane & Marcus, 2013).

A prevailing investment strategy is named value investing. The strategy is based on the IV of stocks being measurable and that their market price may deviate from its IV. Meaning, a value investor intends to identify a mispriced stock which some achieve by analysing the ratio of the book value to the market value of equity, known as the Book-to-Market ratio (B/M). Whereupon, the investor would sell (buy) stocks with low (high) B/M ratio. The different ratios are referred to as growth (low B/M) and value (high B/M) stocks. Since the inception of the value investing strategy by Rosenberg, Reid and Lanstein (1985), research has proven that value stocks have historically outperformed growth stocks in the marketplace over period of time. Fama and French (1992) defend the EMH against the critique of Rosenberg et al. (1985) by arguing that the results generated from the value investing strategy are a consequence of increasing the level of risk.

Another prominent investment strategy is titled as fundamental investing. The strategy is to forecast a firm's future returns or earnings based on available accounting information to appraise a firm's IV. Thereafter, fundamental investors attempt to find stocks whose market price is less (higher) than the firm's IV, thereafter they would enter a long (short) position in the stock (Ball and Brown, 1968).

Piotroski's (2000) study combined the two strategies, value and fundamental investing, and created a new strategy, called F_Score. The strategy was based on readily available accounting information and applied on a value stock portfolio comprising of firms with a B/M ratio in the higher quintile of all firms. The F_Score evaluates a company within the value stock portfolio by analysing the company's performance by nine different financial signals. The nine signals strive to measure the firm's condition regarding profitability, leverage/liquidity, and operating efficiency. This is to identify firms that have the most secure financial position and thus the lowest risk of all value stocks. He showed that by investing in supposedly value stocks of inherent lower risk, one could obtain abnormal market adjusted returns. Thus, he claimed that the F_Score strategy enables an increase in returns without an increase in risk, thereby contradicting the EMH.

2. Theoretical framework

This section will describe the theoretical framework related to Piotroski's (2000) F_Score strategy, which claimed that investors could earn returns exceeding the appropriate risk compensation, consequently rejecting the EMH.

To begin, the EMH and its three distinct forms of efficiency and the anomalies of the hypothesis will be depicted. Thereafter, the strategies of fundamental investing, value investing and the B/M effect are explained. Next, the concept of risk compensation and the capital asset pricing model (CAPM) will be elaborated. The final part of the section will outline the F_Score investment strategy created by Piotroski's (2000).

2.1 Pricing and Valuation of Equity

The following section describes the EMH. Firstly, the EMH, in general, is introduced, and after that, the different forms of efficiency are described in greater detail. This subsection's final part describes anomalies concerning the EMH.

2.1.1 Efficient markets

Fama (1970) was first to establish the hypothesis regarding markets efficiency. The hypothesis was built on the foundation laid by Mandelbrot (1966) and Samuelson (1965). Fama (1970) defined an efficient market as a market catered for securities, where all available information and actual prices closely correspond to the IV of the underlying securities. Furthermore, in an efficient market, the investors are rational and capable of interpreting the information correctly and act accordingly, thereby maximising their returns relative to risk. With the announcement of new information affecting either the market or firm, e.g. firm-specific or systematic information, a security's price will immediately shift to reflect the new information.

Although, some price distortion or arbitrage opportunities may arise due to the actions of irrational investors. With price distortions, investors are given a possibility to gain a risk-free return, known as an arbitrage opportunity. However, price distortions are not indefinite**.** If a price distortion has occurred, the rational investors will seise the arbitrage opportunity and invest accordingly, consequently correcting the price towards its IV, thereby eliminating the arbitrage opportunity (Fama, 1965).

The EMH is commonly divided into three forms of efficiency as to describe the efficiency variations within different markets; these are; weak-form, semi-strong and strong efficiency.

2.1.2 Weak-form efficiency

Weak-form of market-efficiency implies that market data and security prices reflect all historical information. Implying, when the technical analysis is practised, one will be able to find specific patterns, such as the January effect, and general trends of securities over time. However, if technical analysis would be a successful way to predict future prices, then everyone would apply it. As everyone would react similarly on purchasing signals derived from the historical movements, the possibilities of excess returns are taken away, making technical analysis meaningless (Zacks, 2011). Furthermore, a critique of technical analysis is the black swan conundrum, where one cannot predict future events which have never occurred. Thus future price movements may not correspond to their historical movements and thereby rendering a historical analysis without merit.

2.1.3 Semi-strong-form efficiency

A semi-strong efficient market incorporates the implications of the weak-form efficiency. Further on, a semi-strong efficient markets' underlying assets and securities will reflect all publicly available information within their market price. This involves fundamental data such as annual- and quarterly reports, patents held and changes in a company's leadership as well as historical values. Furthermore, changes in stock prices will occur almost instantly with the announcements of new value-relevant information. Consequently, investors cannot apply either technical or fundamental analysis to gain excess returns as one might already expect new information to be reflected in the price (Fama, 1970).

2.1.4 Strong-form efficiency

Strong efficient markets' underlying securities and assets will closely reflect all information, including insider information; ergo security prices and assets will immediately adhere to the announcement of new information and adjust its price as to reflect said information. Furthermore, strong efficiency covers the implications of a weak and semi-strong efficient market. However, strong-form efficiency is very unlikely found outside of theory. For example, if one were under a contract not to disclose any private company information, all information in the marketplace is not accessible thereby making the strong-form efficiency semi-strong. If one were to share said information, they would violate the law by breaching their contract. Thus, it is hard to find a market which exhibits a strong form of efficiency (Bodie et al., 2013).

The overarching consensus of academics and market practitioners view that the general market exhibits the characteristics of a semi-strong efficient market (Bodie et al., 2013).

2.1.5 Anomalies

Since the EMH creation, the mounting numbers of anomalies contradicting the EMH have grown. Anomalies are an event which diverges from the EMH, and for a moment, the stock prices might divert from their IV, and one could gain abnormal returns by identifying these occurrences.

As to identify an anomaly, one must locate a mispricing signal. If there is an anomaly which diverges from the EMH, the risk-adjusted return should be either lesser or greater than zero. Moreover, the anomaly must be statistically tested via a probability test, such as a t-test or of comparable credibility (Zacks, 2011).

The test bears with it a question when interpreting the results, i.e. the adjustment for the portfolio risk. Using CAPM to adjust for portfolio risk can lead to incorrect conclusions, that some portfolio strategies achieve abnormal returns, when in fact it is the risk adjustment procedure which failed. This is due to the beta and expected return differing from CAPM's predictions. The problem when defining an anomaly is referred to as the joint hypothesis problem (Fama, 1970). The joint hypothesis problem claims that a test for anomalies is of joint character, consisting of both efficient market and risk-adjustment procedure. The risk-adjustment procedure does not and cannot claim that the CAPM reflects all risk. Thus, a rejection of the efficient market can be a result of misspecification within the CAPM rather than an issue with the efficient market itself. Usually, the risk-adjustment technique is based on more questionable assumptions than the EMH. As such, the market can be inefficient, or the asset pricing model is incorrect, by rejecting the procedure, one cannot conclude the market's efficiency. In sum, when a security is creating abnormal returns, it does not necessarily mean an anomaly is the cause of it, as the CAPM may not include all the underlying risk factors (Fama, 1970).

2.2 Fundamental investing

A fundamental investor tries to find stocks which market price deviates from the firm's IV and invests accordingly. The investor uses information concerning the current and prospective profitability of a company to determine its IV. Furthermore, the investor uses relevant multiples to compare the pricing of a stock against other firms in the same sector to derive the IV. However, the fundamental investor mainly focuses on the firm's fundamentals, i.e. all information that contributes to the valuation to achieve an understanding of the firm's well-being and thereby deriving the IV. It is contradictory to the EMH, but there are examples of several investors who have continuously outperformed the market using this strategy, there among Benjamin Graham and Warren Buffet. Bodie et al. (2013) argue that it is the ongoing search for mispriced securities that maintains an efficient market.

Ball and Brown (1968) showed an indication that accounting earnings are related to the price of the stock. Subsequently, Ou and Penman (1989) agreed that financial statements can indicate a firm's value, and showed that stock prices can deviate from it at times. Ou and Penman (1989) give some evidence that a financial statement captures values which are not reflected in stock prices. Since deviant prices gravitate to the fundamental value, an investment strategy based on identifying firms with deviating price from its IV, can thereby produce abnormal returns. Greig (1992) disagreed with Ou and Penmans' (1989) statements, as he argued that the returns could be explained and be regarded as normal if one were to account for a firm's size and beta, and as such, by adhering to these variables, the returns could be regarded as normal.

2.3 Value Investing

B/M is defined as the ratio between book value per share to market price per share. Rosenberg et al. (1985) evaluated strategies to prove markets inefficiency thereby contradicting the work of Fama (1970). Although, only one of the strategies are of interest for this thesis. The strategy evaluated by the researchers was to buy (long) high B/M firms and short-selling low B/M firms. The strategy did show persuasive evidence of market inefficiency, thus giving proof of high B/M firms outperforming low B/M firms. Furthermore, the findings regarding high B/M firms were proven to have explanatory power concerning the return of an asset by Fama and French (1992).

Following this, Lakonishok, Shleifer, and Vishny (1994) contributed to the research regarding value investing in general and B/M investing amongst other strategies. The researchers did, to a certain extent, prove that value investing yields higher returns due to the strategies exploiting suboptimal behaviour of the typical investor and not due to the inherent asset's level of risk. Thereafter, they argued that a contrarian strategy as value investing outperform a glamour strategy, i.e. high growth, is because the investing community tends to overestimate future growth. The investing community is often excited about assets that perform well and tend to consider they will continue to do so. Similarly, the community tends to overreact when receiving negative news and therefore oversell assets which have underperformed. This theory is evaluated against the more common perception that value stocks are more fundamentally risky and therefore should give excessive returns. Lakonishok et al. (1994) find few, if any, indications that this should be the case. The authors motivate their findings by behavioural psychology for the group of individual investors and by agency problems for institutional investors. Concluding their research, they show that market participants consistently overestimate future growth rate of glamour stocks versus the growth rate of value stocks. Moreover, their findings show that a value stock produces an additional return of 10-11 % per year.

2.4 Capital Asset Pricing Model

The CAPM describes the relationship between the expected return of an asset and the return of a broad market portfolio consisting of all available assets. CAPM was introduced by Sharpe (1964), Lintner (1965) and Mossin (1966) and is based on the theory of efficient markets by Markowitz (1952). Sharpe (1964) and Lintner (1965) showed that the risk of an asset could be broken down into two groups:

(i) Firm-specific/idiosyncratic risk, i.e. risk which can be eliminated/mitigated through diversification.

(ii) Systematic risk, i.e. risk which cannot be eliminated through diversification

From this, they concluded that investors weighed their portfolios as a combination of the two groups as to acquire their desired level of risk, known as risk aversion. Furthermore, the CAPM gave a theoretical definition of the compensation an investor is to expect of an investment in a stock and its inherent risk, see equation (1).

$$(1) \qquad E(R_a) = E(R_f) + \beta_a * (E(R_m) - E(R_f))$$

The variable $E(R_a)$, denotes the expected return for an investment in asset A. $E(R_f)$ stands for the risk-free rate while $E(R_m)$ denotes the expected return of the market portfolio. The difference between $E(R_m)$ and $E(R_f)$ can be referred to as the market risk premium. Beta (β_a) describes the asset A's covariance with the market's returns volatility, see section 2.4.1 for a detailed description of beta.

As investors are only compensated for systematic risk and the highest risk and return trade-off is found using completely diversified market portfolio and leverage, implying that the optimal portfolio for an investor to hold is the market portfolio. Although depending on the investor's risk aversion, they may choose to construct their portfolio according to their risk aversion. E.g. an investor which is very risk-averse would rather seek to invest the majority in the risk-free asset whilst investing a minimal amount in the market portfolio, thus having a smaller beta-coefficient than the market (Zacks, 2011).

2.4.1 Beta

The beta-value, or the beta coefficient, is a historical variable which describes the relationship between a security's return with the overall market (index) return.

As mentioned in section 2.4 Capital Asset Pricing Model, the beta-coefficient is often used in tandem with the application of the CAPM, as to determine the required rate of return for the level of systemic risk taken as shown in equation (1). Meaning, the greater the beta, the higher the expected rate of return is required to compensate for the level of risk taken.

A beta coefficient of 1.0 indicates the asset's price movements are identical to the compared index, e.g. the market index. A beta coefficient greater (lesser) than 1.0 indicates larger (smaller) asset price movements than the market index. When the beta coefficient is equal to 0, the returns of the asset is indifferent to the fluctuations of the market index, thus making it a risk-free asset. One way to calculate the beta coefficient is with equation (2) (Crouhy, 2014):

$$\beta_a = \frac{\mathrm{Cov}(R_a : R_j)}{\mathrm{Var}(R_j)} \qquad (2)$$

According to equation (2), the asset A's beta is a measure of the covariance between the asset's return and the market j index return, divided by j market's variance. Hence, beta is a relative measure of the risk of an asset normalised by the total market risk.

2.5 Fama and French's Three-Factor-Model

Fama and French (1992) show that the asset's sensitivity to market risk, says little regarding average returns for stocks. Their bottom-line results show that size and B/M equity give some description to the average returns on NYSE, Amex, and NASDAQ during the 1963-1990 periods. Consequently, they added the two additional risk factors to the CAPM which took into consideration the B/M ratio and the firm size as to improve its reliability. With the introduction of the new factors, Small-Minus-Low (SML) and High-Minus-Low (HML), to the CAPM, the three-factor model was created (Fama and French, 1992).

2.6 F_SCORE

The F_Score was initially introduced by Piotroski (2000). In his research, he introduced a method aiming to find companies that would be likely to outperform the investigated sample. The method would also notice those companies that would perform worse than the examined sample. Combining his discoveries, he created an investing strategy in which he invests in companies with a high F_Score while shorting those with a low F_Score. The strategy would have generated a 23 % annual return between 1976 and 1996.

The F_Score model is based on both the theory of value investing (high B/M) and fundamental analysis through its use of financial statements. Piotroski (2000) wanted to examine if a simple accounting-based fundamental analysis strategy, when applied to a portfolio consisting of high B/M firms, could outperform the original B/M portfolio as such. The reason to examine his method with only high B/M companies in the sample is that these firms, as a group, are often less followed by the analyst community and receive a low level of interest by investors. He argues that these firms have limited access to the informal information channels and that their information may be viewed as less credible due to recent poor performance. Furthermore, Piotroski means that these high B/M firms tend to be financially distressed. Because of abovementioned arguments, the valuation of these firms mostly focuses on accounting fundamentals which can be easily obtained from historical financial statements.

The F_Score is a system that combines a company's performance in nine different financial signals. The outcome of each signal is binary, i.e. 0 or 1 depending on whether the signal is positive or negative. If a signal is interpreted as positive, it is assigned the value 1. Respectively if the signal is negative, it is assigned the value 0. After all the nine signals are examined, the F_Score is calculated as the sum of the individual binary signals, where 0 is the worst and 9 the best score. The choice of binary factors might not be the most optimal way to separate high from low performers. However, Piotroski (2000) argue that a factor analysis approach has cost in terms of feasibility. The nine signals strive to measure the firm's financial condition regarding its profitability, leverage/liquidity, and operating efficiency. Each signal is as previously said given a value of 0 or 1 depending on whether it is negative or positive. The aggregate calculation of the F_Score is presented in equation (3), and each variable's equation is found in the table (1). Furthermore, each signal will be described in the following subsections.

$$F_{Score} = F_{ROA} + F_{\Delta ROA} + F_{CFO} + F_{ACCRUAL} + F_{\Delta MARGIN} + F_{\Delta TURN} + F_{\Delta LEVER} + F_{\Delta LIQUID} + EQ_{OFFER} \quad (3)$$

2.6.1 Signals regarding profitability

Piotroski (2000) argue that a firm which currently generates positive profits or cash flow demonstrates the ability to generate funds through operating activities. Furthermore, an improvement of the earnings could suggest an improvement in the firm's ability to deliver positive future cash flows. To measure the signals regarding the firm's profitability, Piotroski (2000) uses the four variables ROA, CFO, ΔROA and ACCRUAL which are defined as:

- ROA – Net income before extraordinary items

- CFO – Cash flow from operations
- ΔROA – Current year's ROA less the prior year's ROA
- ACCRUAL – Current year's ROA less CFO

Furthermore, a positive value of the variable ACCRUAL gives a negative signal regarding the firm's future profitability (Sloan, 1996). Piotroski argue this might be more accurate for high B/M companies where the incentives to manage earnings through positive accruals are strong. For ROA, CFO and ΔROA, their respectively binary contribution to the F_Score are 1 if positive and 0 if negative. F_ACCRUAL equals 1 in the case where CFO is greater than ROA and 0 otherwise.

2.6.2 Signals regarding leverage, liquidity and source of funds

These signals are designed to describe the change in capital structure and the firm's likelihood to meet future debt service obligations. Piotroski (2000) argues that an increase in leverage, a deterioration of liquidity and the use of external financing is a negative signal about financial risk. To describe the firm's performance in this section Piotroski (2000) introduces three variables, ΔLEVER, ΔLIQUID, and EQ_OFFER. The variables are defined as stated below:

- ΔLEVER – Change in ratio of total long-term debt to average total assets
- ΔLIQUID – Change in ratio of current assets to current liabilities
- EQ_OFFER – Change in common equity

Myers and Majluf (1984) show that when attempting to raise external capital, a financially distressed firm displays an incapability to generate adequate internal funds. Thus, an increasing ratio of total long-term debt to average total assets indicates a negative signal and the correspondingly F_Score value are assigned the value 0. If the ratio decreased from last year, F_ΔLEVER equals 1.

Furthermore, Piotroski assumes that an improvement in liquidity, ΔLIQUID >0, is a positive signal and therefore its contribution to F_Score equals 1. Naturally, the same reasoning goes for a deterioration of liquidity and consequently ΔLIQUID < 0 implies an F_ΔLIQUID value of 0. The indicator EQ_OFFER is defined to equal 1 if the firms did not issue common equity in the previous year. The argument for this is analogous to that of ΔLEVER. Also, it implies a negative signal of their poor financial situation if the firm is willing to issue equity when their stock prices are somewhat depressed (Miller & Rock, 1985).

2.6.3 Signals regarding operating efficiency

The following signals intention is to measure changes in the operating efficiency. Piotroski introduces the variables ΔMARGIN and ΔTURN to reflect this change and defines these as follows:

- ΔMARGIN – Current gross margin ratio (gross margin scaled by total sales) less the preceding year's gross margin ratio
- ΔTURN – Current year asset turnover ratio (total sales scaled by beginning of the year total assets) less the preceding year's turnover ratio

If ΔMARGIN is positive F_ΔMargin equals 1 considering that it shows a potential improvement in factor costs, a reduction in inventory costs or a rise in the price of the firm's product. Hence, a negative ΔMARGIN value implies that F_ΔMargin equals 0. Higher productivity from the asset base can show itself with an improvement of asset turnover. Therefore F_ΔTURN equals 1 if ΔTURN is positive, zero otherwise.

2.6.4 Summary

In table (1), the definition of each signal and its respective contribution to the F_Score depending on the signals outcome is summarised.

Following equation (3), the F_Score is calculated as the sum of each signal's corresponding binary value. This means that each firm's F_Score ranges from zero to nine. From the broader high B/M sample, Piotroski identifies the firms with the highest F_Score (8-9) and expects those too, as a group, to perform the best considering their strong results. Furthermore, he classifies low F_Score firms as those with an F_Score of 0 or 1 and expects them to perform the worst.

Firstly, the Piotroski tests the performance of the stronger F_Score against those with a low F_Score. Thereafter, he compares the result of the portfolio consisting of firms with a high F_Score against the entire high B/M sample. The results show with a 1 % level of significance that a portfolio consisting of firms with high F_Score generates higher returns than a portfolio with low F_Scores by an annual mean return of 23 %. Furthermore, the portfolio produces a higher return by 0.075 with the same 1 % level of significance compared to the portfolio consisting of high B/M assets. The two tests were conducted using a traditional parametric t-test and an empirically derived distribution of potential return differences.

Table 1 – Calculations of F_Score variables

F_{signal} when Signal <0	0	0	0	1	1	0	1	0	0

Signals	Definition	Equations	F_{signal} when Signal >0
ROA	Net income before extraordinary items	$ROA_t = \frac{\text{Net income before extraordinary items}_t}{\text{Assets}_{t-1}}$	1
CFO	Cash flow from operations	$CFO_t = \frac{\text{Cash flow from operations}}{\text{Assets}_{t-1}}$	1
ΔROA	Current year's ROA less the prior year ROA	$\Delta ROA_t = ROA_t - ROA_{t-1}$	1
ACCRUAL	Current year's ROA less CFO	$\text{Accrual}_t = ROA_t - CFO_t$	0
ΔLEVER	Change in ratio of total long-term debt to average total assets	$\Delta \text{Lever}_t = \frac{\text{Long} - \text{Term Debt}_t}{\frac{1}{2}\text{Assets}_t + \frac{1}{2}\text{Assets}_{t-1}} - \frac{\text{Long} - \text{Term Debt}_{t-1}}{\frac{1}{2}\text{Assets}_{t-1} + \frac{1}{2}\text{Assets}_{t-2}}$	0
ΔLIQUID	Change in ratio of current assets to current liabilities	$\Delta \text{Liquid}_t = \frac{\text{Current assets}_t}{\text{Current liabilities}_t} - \frac{\text{Current assets}_{t-1}}{\text{Current liabilities}_{t-1}}$	1
EQ_{OFFER}	Change in common equity	$EQ_{OFFER_t} = \text{Common shares outstanding}_t - \text{Common shares outstanding}_{t-1}$	0
ΔMARGIN	Current gross margin ratio less the prior year's gross margin ratio	$\Delta \text{Margin}_t = \frac{\text{Sales}_t - \text{COGS}_t}{\text{Sales}_t} - \frac{\text{Sales}_{t-1} - \text{COGS}_{t-1}}{\text{Sales}_{t-1}}$	1
ΔTURN	Current year asset turnover ratio less the prior year's turnover ratio	$\Delta \text{Turn}_t = \frac{\text{Sales}_t}{\text{Assets}_{t-1}} - \frac{\text{Sales}_{t-1}}{\text{Assets}_{t-2}}$	1

3. Methodology

This section describes the purpose of the thesis and how we work towards that purpose. At first, we describe the purpose and secondly, the method for data collection and choice of time period. Subsequently, we describe the B/M requirement we required of the firms. After that, we describe the calculation of F_Scores and define our portfolios and the benchmark portfolios. Following that, we describe how the risk-free interest rate was retrieved, the use of CAPM-theory and calculate the Jensen's alpha. Subsequently, we explain the use of Treynor ratio and biases. At last, we describe the statistical methods used in the chapter.

3.1 Purpose

The thesis objective is to examine whether Piotroski's investment strategy: F_Score, which have been tested on the U.S. stock market, is applicable on the smaller sized Swedish stock market and whether the strategy can generate a better risk-adjusted rate of return. Additionally, we seek to research the Swedish economy in different states such as in a recession and financially strong years and a different period and geographical market as to determine whether Piotroski was plagued by data-snooping,

To evaluate whether the investment strategy does generate a better risk-adjusted rate of return on the Swedish stock market, the returns will be benchmarked against our portfolios, see table 3 for a list of the benchmark portfolios. Furthermore, the returns will be tested, adjusting for risk, using CAPM as well as the Treynor ratio. The returns will be presented and evaluated as annual returns including dividends over a one-year buy-and-hold period and not over the entire time period**.** After that, we conduct a t-test as to evaluate the reliability of our results.

3.2 Data collection and time period

To retrieve the necessary accounting information of firms to evaluate Piotroski's F_Score investment strategy, we utilised Thomson Reuters Datastream (DS) to gather the information for the investigated period ranging from 2004 to 2016. We will include all firms on the Swedish stock market with sufficient data available to calculate the necessary variables for F_Score and B/M ratios. Consequently, firms which did not have sufficient data were excluded in the sample selection.

The reason for choosing the period ranging from 2004 to 2016 is that we desire to have the data as recent as possible. Having the sample stretch over a sufficiently long-time period enables us to determine whether the results generated by the F_Score investment strategy are persistent over time which, according to Piotroski's (2000) statement, that the F_Score's results are robust over time (Piotroski, 2000).

To analyse the years 2004-2016**,** the dataset for the period needed to be extended. Thereby, we utilized two different sampling periods which are referred to as the primary sample, consisting of data covering the period between the 1st of May 2004 and the 1st of May 2016. The second period is referred to as the extended sampling period, consisting of data covering the period between the 1st of May 2002 and the 1st of May 2017. The period expansion is due to financial information for the following year after 2016 is needed, e.g. the 1st of May 2017's stock price and dividends are required to calculate the returns for 2016, see equation 6. Furthermore, the reason for the extended sampling period to begin from the 1st of May 2002 is to accommodate F_Score variables, such as ΔTURN and ΔLEVER, which needs information two years prior to the chosen starting date, see table 1.

Moreover, we chose to retain the same starting point as Piotroski in his study, which is the 1st of May. The reasoning is that the 1st of May is close to the end of the reporting period in Sweden. Thus companies would likely have submitted and published the previous year's annual report by then. Furthermore, we presume that most companies have similar fiscal year endings as to regular calendar year and that the annual report is created within five months of the fiscal year-end. In addition, DS lacks the data regarding the fiscal year ending for each company and their publishing date for their annual report. Although, we are aware that companies have different fiscal year endings other than the 31st of December, but we reckon that quarterly reports from firms with different fiscal year endings would provide sufficient information to conduct our analysis. Besides, we believe that if we choose different dates of purchase for each stock as to adhere to each firm's fiscal year endings, it will deteriorate the results of our analysis as it would, in turn, affect the calculations of returns.

Table 2 –Data sample, number of firms

Original number of firms:	
Total number of firms included	**1226**
Adjustments	
After excluding firms lacking sufficient account information, secondary quotes and ETF etc.	**-628**
Final Sample	
Total number of firms included:	**598***

*This is before the B/M requirements are applied.

3.3 B/M requirement

Differing from Piotroski (2000), where he computed the F_Scores each year for firms which were in the top B/M ratio quintile of all firms, we will solely compute the F_Scores for firms which qualify for the set B/M ratio of requirement. The B/M ratio we will require firms to have is ≥0.8, which is approximately higher than the average of all firms, furthermore, the limit to at least 0.8 as to ensure that firms are either close to or are value stocks. The reason for differing from Piotroski in this manner of B/M computation is that we seek a consistent level of requirement for the ratio each year, which is then to be computed for F_Score. This is instead of the B/M requirement ratio for F_Score computation by Piotroski (2000), which had varying levels of B/M ratios within the portfolios due to the severing point for firms. After all the firms' B/M ratios have been computed, those who fulfil our requirements will be included in a portfolio and subsequently have their F_Score computed.

3.4 F_Score calculation

When choosing F_Score's level of inclusion for low, medium and high scoring firms, we again choose to differentiate us from Piotroski (2000) by expanding the level of inclusion for low and high scoring firms. By expanding the cut-off limits of the F_Score, it would include more firms in the high B/M portfolios and thereby improve the reliability and robustness of our results. In addition, it would compensate for the sample size of the Swedish stock market is less extensive than the size of the American stock market which was Piotroski's investigated market, see table 4.

The nine variables in the F_Score model are calculated as described in table 1, and as mentioned, only applied to firms with a B/M ratio of ≥0,8. Moreover, every firm with a ratio of ≥0,8 at year t-1 is utilised to compute the F_Score for year t. Each year over the primary sample period, the F_Score calculations are conducted on firms, and each variable's binary score will be awarded. After that, the aggregated F_Scores are ranging from 0 to 9 will be computed. Each firm's aggregated F_Score is thereafter utilised to segregate between low (0-3), medium (4-5) and high (6-9) scoring firms in respective year's B/M≥0,8 portfolio. Subsequently, firms which receive low and high F_Scores will be divided into their respective F_Score levels and incorporated into two separate equal-weighted portfolios consisting of the firms, see table 3. The equal-weighted portfolios will have a buy-and-hold strategy, and the firms will be included in their portfolio on the 1st of May at the beginning of t year and kept for a one-year (t+1) holding period. Moreover, since our focus is to evaluate the low and the high F_Scores, we will not create a portfolio consisting solely of the firms with medium scoring. However, we will include all firms which achieve a B/M ratio of ≥0,8 in a portfolio, F_All. Additionally, we are going to create a hedged portfolio, F_Hedge, that every period places an equal amount long in respective years F_High portfolio as the amount shorting F_Low. With the F_Hedge portfolio, the amount received when entering a short position in the F_Low portfolio will be utilised to finance the long position of the F_High portfolio. Thus, we will have self-financing hedge positions each year. Consequently, the F_Hedge portfolio will have a net asset exposure of zero. After the holding period, the portfolios will be reorganised as to adapt to the changes in firms' B/M ratios and their respective F_Score results.

In total, we will create four portfolios from the results of the F_Score computation each year, but only three of them will be evaluated whereas one will be utilised as a benchmark portfolio together with the market portfolio; see table 3.

Table 3 – Evaluated portfolios

Evaluated portfolios:	
F_Low_t	Equal-weighted portfolio consisting of firms with F_Score's between 0-3
F_High_t	Equal-weighted Portfolio consisting of firms with F_Score's between 6-9
F_Hedge_t	Portfolio weight consisting of 50 % F_High and 50 % short F_Low portfolio
Benchmark portfolios:	
F_All_t	Portfolio consisting of all firms with a B/M ratio≥0,8

MP	Value-weighted market portfolio (market index)

3.5 Market index and return calculations

When selecting a market index to use as a benchmark to evaluate F_Score's performance, a few things need to be considered. First and foremost, the index needs to cover our select firms within the Swedish stock market. Secondly, the index needs to have sufficient data covering the extended sample period. Moreover, the index needs to consider dividends, stock splits, and share repurchases etc.

To receive the optimal proxy as the market portfolio, we have chosen to create the market index ourselves, consisting of the data, firms and years covered by the extended sample period thereby excluding the possibility of a chosen index including firms which we do not include in our sample. The returns of our market index were weighted according to the firms' respective market value each year, to the entire market value. Thereby, we will have a market return index which will be adjusted to reflect all capital actions such as dividends and stock repurchases.

No adjustments for brokerage, tax or any other transaction fees will be made when conducting the calculations for returns. Since the portfolios are reorganised once a year, it will not produce any significant transactions cost, and furthermore, we believe these adjustments lies outside of the perimeter of our research.

The value-weighted market return for each year is calculated as in equation (4):

$$(4) \qquad \text{Market return}_t = \sum_{k=0}^{n} W_i * P_i + W_j * P_j + \cdots + W_k * P_k$$

W_i denotes the ratio of asset i's market value and the market value of all assets. Pi denotes the return of asset i, see equation (5).

Thereafter, we will compute firm-specific raw returns and market-adjusted returns as a one-year buy-and-hold strategy as to replicate our F_Score trading strategy over the extended sample period.

$$(5) \qquad \text{Raw returns}_t = \frac{(P_t - P_{t-1}) + D_{t-1}}{P_t}$$

$$(6) \qquad \text{Market} - \text{adjusted returns}_t = \text{Raw returns}_t - \text{Market returns}_t$$

P_t refers to the price of the underlying asset today, whilst P_{t-1} refers to the previous period's price. D_{t-1} denotes the dividends received from the previous period.

The firms' returns within the F_Score portfolios are calculated according to equation (5). Thereafter, similarly to equation (4), although equally-weighted, as to obtain the returns of F_High, F_Low and F_All.

The returns for the one-year buy-and-hold portfolios; F_Low, F_High, and F_All, are calculated as in equation (5). The returns for the F_Hedge position are calculated according to the following equation (7):

$$(7) \qquad \text{Return } F_{\text{Hedge}_t} = (\text{Return } F_{\text{High}_t} - \text{Return } F_{\text{Low}_t})$$

3.6 Risk-free rate

The risk-free rate used was created by using Riksgälden's website to retrieve the historical Swedish treasury bills, ranging over the periods covered by the extended sampling period, known as statsobligationer. We seek to have the duration of the risk-free rate to have a similar maturity date as the portfolio returns; we will average the different changes in rates throughout the period to create the chosen year's risk-free rate. E.g. to achieve the risk-free rate for 2007, the risk-free rates between the 1^{st} of May 2007 and 1^{st} of May 2008 are selected and averaged.

3.7 CAPM and Jensen's alpha

CAPM, as mentioned in section 2.4 Capital Asset Pricing Model, expresses the expected return in accordance with equation (1). Jensen (1968), under the assumption that the CAPM is valid, showed that the realized return of an asset or portfolio (R_p) is a linear function. The lineaar function consists of the risk-free rate (R_f), the beta (β) (i.e. system risk), realized return of the market (R_m - R_f) and a random error term (ε) which has an expected value of zero. Thereby, he altered the CAPM equation by enabling a non-zero constant in his regression analysis, which could be utilised to determine whether an asset or portfolio could generate abnormal returns. The abnormal returns are referred to as alpha value. If the value is positive, then the portfolio is earning excess returns to the market and vice versa. To clarify, Jensen's alpha may be viewed as the difference between realised returns and the expected returns. The alpha captures all factors which are not included in the market model whether it is due to an anomaly or not.

Under the assumption that CAPM is valid, Jensen's alpha is calculated using equation (8), and is the one we will utilise to check for abnormal returns.

$$R_{p_t} = R_{f_t} + \alpha + \beta(R_{m_t} - R_{f_t}) + \varepsilon_t \qquad (8)$$

3.8 Treynor ratio

The Treynor ratio is often used to compare portfolios' ability to generate the greatest return in excess of the risk-free rate for any given level of risk, whereby one can select the most efficient portfolio.

The Treynor ratio is a risk-adjusted measurement of a return based on systematic risk as the ratio utilises the beta-coefficient, see section 2.4.1 Beta, of a portfolio to measure its level of risk. The ratio is based on the premise that the inherent risk to the entire market, I.e. beta, should be penalised as it cannot be avoided through diversification within the portfolio. Thus, the ratio will inform us whether the performance, regarding the systemic risk of a portfolio, is superior to the other and how efficiently the capital is used. Equation (9) is to compute the Treynor ratio (Craig, 2003):

$$\text{Treynor ratio} = \frac{R_P - R_F}{\beta_P} \quad (9)$$

Equation (9) utilises the average annual return in excess of the risk-free rate generated by a portfolio in relation to the amount of beta in our F_Score portfolios. When the ratio is high, it gives us an indication that the investment has generated high returns on every level of market risk taken.

3.9 Biases

When researching a trading strategy by back-testing using historical data points, there may occur possible biases in the results due to the data. First and foremost is the look-ahead bias, also known as foresight bias. The bias refers to the use of information or data in a study which would not be available at the time of a portfolio's formation, which therefore could render inaccurate results in the study (Andreu, Ferruz & Vicente, 2010). This thesis, therefore, might enable the look-ahead bias to occur as our data is gathered from annual reports and as companies differ with their release dates for their annual reports, could be an issue. However, as aforementioned, the date for the portfolios' creations are set on the 1st of May each year, thereby giving sufficient time for most companies to release their annual reports and investors enough time to act upon the new information, thereby mitigating the issue of the look-ahead bias.

The second possible bias is the survivorship bias. The bias is regarding the possibility of firms delisting from a stock exchange during the placement year and may either be excluded beforehand or when the return of the portfolios is to be calculated, consequently, our study could suffer from said bias. Although, as DS includes firms which delist during a year in addition to our chosen investment date of the 1st of May would thereby contain delisted firms. Additionally, firms' returns upon delisting are to be assumed as zero as to recreate Piotroski's (2000) actions. Thus, by including companies which have delisted and currently listed firms, the issue of survivorship bias is mitigated. Furthermore, to solve the bias, it was motivated by Piotroski's (2000) findings that the average delisting return of firms with high F_Scores was generating a return of 2.2 % and firms with low F_Score were generating -0.87 %. Thereby, suggesting the possibility of delisting may have already been incorporated into the stock price when the delisting occurred (Piotroski 2000).

3.10 Statistics

For our statistical analysis, we have used Excel and Matlab. We use Excel for F_Score computation and calculating each portfolio's returns, market value and their standard deviations. Matlab is used for testing for normality and conducting t-tests.

To test for normality, we will perform a chi-square goodness-of-fit-test at the 5% significance level. The null hypothesis state that the investigated vector comes from a normal distribution with a mean and variance estimated from x. If the null hypothesis should be rejected, the alternative hypothesis is strengthened, and we cannot continue with the assumption of normality.

When we conduct a t-test to evaluate whether a particular return is higher than another, we evaluate the corresponding intervals both at significance level 95%

and 99%. When we examine whether the Treynor ratio is higher for a portfolio in comparison with another, we present the p-value because we consider the interval being of less interest. The t-test is consistently one-sided because we want to evaluate if a particular variable is either significantly higher or lower than another.

4. Results

In this section, we present our results and discuss our findings. First, is data statistics introduced and discussed. Secondly, we test the different portfolios for normality. Further on, we evaluate the absolute return of F_Low and F_High against the benchmark portfolios F_All and MP. After that, we evaluate the actual return of each portfolio against the expected return according to CAPM. Lastly, we evaluate each portfolio's risk-adjusted returns against F_All.

4.1 Data

In table 4, the distributions of firms for each F_Score value are presented. The distributions shown are both before and after reducing the sample according to our B/M requirement, and moreover, seem to follow a normal distribution. Although the distribution is to an extent skewed to the left as most of the observation points fall between a F_Score of 3 and 7. The distribution is visualised in figure 1.

Table 4 – Distribution of F_Score observations

F_Score	All observations	Firms with B/M>0.8	Piotroski
0	0	0	57
1	6	1	339
2	64	11	859
3	244	69	1618
4	475	123	2462
5	674	171	2787
6	552	143	2579
7	333	226	1894
8	100	29	1115
9	1	1	333
F_Low	314	81	396*
F_High	986	399	1448*
F_All	2449	774	14043

*Note that Piotroski defines low and high F_Scores as 0-1 and 8-9 respectively whilst we define low and high as 0-3 and 6-9 respectively.

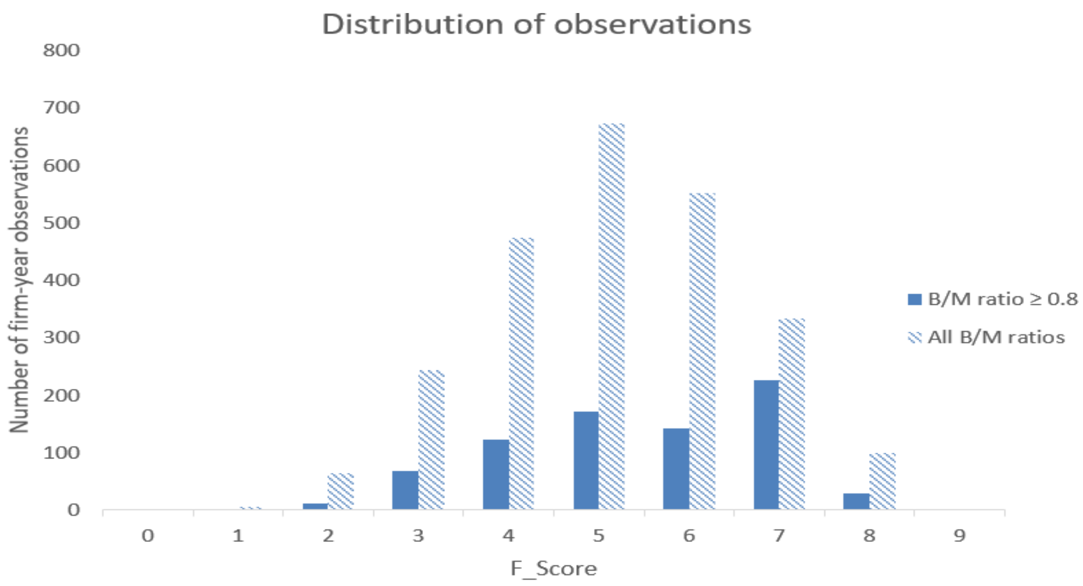

Figure 1 Distribution of observations

Table 5 shows the average annual returns for each F_Score and their standard deviation between observation points. Worth mentioning is the averaged return for F_Score in the intervals [0, 3], [6, 9], and [0, 9], as the returns for [0, 3] seems to be substantially lower with an average return of 0.3% whilst [6, 9] and [0, 9] shows an average return of 31.5% and 25.3% respectively. The standard deviation for the categories seems to be more alike, where the standard deviation is ranging from 49,8% to 56,4%. This might indicate that F_Low will as expected perform lower than F_High and F_All, both in absolute terms and risk-adjusted terms. Furthermore, this might indicate that F_Hedge will produce a desirable risk-adjusted return. These indications will be evaluated in a separate section. Worth noting the fact that the sample only contains one firm which obtained the highest F_Score value and it experienced a great negative return. This together with the high standard deviation amongst firms informs the reader that solely the F_Score should not be used to determine the success of the individual firm. It should rather be applied to a broad portfolio lowering or increasing the weight towards certain firms.

Table 5 – Average annual returns for each F_Score and the risk-free rate

F_Score	n total	Average annual returns each year	Standard deviation amongst asset
0	0	0.0%	0.0%
1	1	-33.3%	0.0%
2	11	-12.5%	35.3%
3	69	2.8%	58.9%
4	123	7.8%	42.4%
5	171	35.1%	61.6%
6	143	32.6%	55.8%
7	226	29.8%	43.7%
8	29	41.0%	61.5%
9	1	-23.3%	0.0%
0–3	81	0.3%	56.4%
6–9	399	31.5%	49.8%
0–9	774	25.3%	52.3%
Risk-free rate		3.05%	

In table 6 we present the calculated annual return for each year and each portfolio. We also present mean and median return for each portfolio, and the standard deviation from it is mean among the different years. Furthermore, the beta value for the entire period is presented. The parameter CAPM equals the expected annual return for each portfolio according to CAPM theory, see equation (1). For F_Low (F_High) we see that the actual mean return is lower (higher) than CAPM for F_Low (F_High) as well as it is lower than the other portfolios. This gives us further indications that F_Low might perform poorly, both considering absolute return and beta-adjusted return. Considering F_High, the values gives us an indication that it performs better than the corresponding beta-adjusted return. It also seems to produce better results than the other portfolios, although the difference is narrower. F_Hedge has a beta value that is close to zero which indicated that the market risk is almost reduced. This gives us an indication that the portfolio might achieve its purpose. Even though the beta is low, the mean return is 26.5%. The indications presented will be further evaluated.

Table 6 – Each portfolio's return each year of the holding period

Year	F_Low	F_High	F_Hedge	F_All	MP
2004	20.3%	43.6%	23.3%	39.2%	38.1%
2005	60.1%	74.7%	14.6%	84.8%	185.4%
2006	26.8%	38.5%	11.7%	43.4%	37.8%
2007	-16.8%	-9.5%	7.3%	-10.4%	1.4%
2008	-15.2%	-27.7%	-12.5%	-29.7%	-49.3%
2009	-26.6%	74.8%	101.4%	56.0%	15.6%
2010	12.2%	22.5%	10.3%	16.3%	-26.4%
2011	-36.4%	-4.1%	32.3%	-10.1%	-33.9%
2012	-23.8%	20.2%	44.0%	11.0%	17.8%
2013	42.7%	42.5%	-0.2%	39.6%	24.8%
2014	-11.4%	58.5%	69.9%	20.6%	27.3%
2015	29.1%	15.0%	-14.1%	15.1%	12.8%
2016	5.7%	62.4%	56.7%	42.8%	27.4%
Mean	5.1%	31.6%	26.5%	24.5%	21.4%
Median	5.7%	38.5%	14.6%	20.6%	17.8%
St. deviation	28.4%	31.2%	33.7%	29.7%	54.3%
Beta	0.35	0.39	0.04	0.45	1
CAPM	9.6%	10.3%	3.8%	11.4%	21.4%

4.2 Normal distribution test

In this section, we perform a hypothesis test considering the portfolio's returns goodness-of-fit to a normal distribution.

H_0 (x): Vector x comes from a normal distribution

H_1 (x): Vector x does not come from a normal distribution

Vector x denotes the yearly returns for each portfolio. The result h equals 1 if the test rejects the null hypothesis at the 5% significance level, and 0 otherwise. The result of the test for each portfolio is presented in table 7.

Table 7 – Test for normal distribution.

x	F_Low	F_High	F_Hedge	F_All	MP
h	0	0	0	0	0

Since we could not reject our null hypothesis for any of the portfolios, we continue our statistics with the assumption of normality for each portfolio's return.

4.3 Absolute returns

During this section, we evaluate the absolute returns of F_High and F_Low. We begin by evaluating F_High and thereafter continuing with F_Low.

4.3.1 F_High versus F_Low, F_All, and MP

In this section, we conduct a t-test to evaluate if F_High has had significantly higher returns than F_Low, F_All, and MP. The hypothesis is stated below, where x denotes the difference between the evaluated portfolio and its comparable.

H_0: $x = 0$

H_1: $x > 0$

Table 8 – T-test statistics considering the absolute returns for F_High versus F_Low, F_All and MP.

Evaluated portfolio	**F_High**		
Comparable	F_Low	F_All	MP
Confidence interval 95%	(9.86, infinity)	(1.04, infinity)	(-10.37, infinity)
Confidence interval 99%	(1.46, infinity)	(-2.04, infinity)	(-20.75, infinity)
P value	0.0075	0.0296	0.1970
H_0	Rejected at significant level 1%	Rejected at significant level 5%	Not rejected

In table 8 we learn that the null hypothesis is rejected at a significance level of both 1% and 5% for F_High versus F_Low and F_All respectively. This strengthens the alternative hypothesis H_1. The test shows that the absolute returns are significantly higher for F_High in comparison with F_Low and F_All. This implies that F_High has had significantly higher returns than F_Low and F_All. This means that a value investor could experience greater returns when investing in an aggregated portfolio weighted towards firms with a high F_Score. Furthermore, we could not reject the null hypothesis at any desirable level of significance when comparing the absolute return of F_High with the returns of MP. Thereby we experience an inability to show whether the strategy of value investing in general and F_High more specifically, can outperform the market portfolio.

4.3.2 F_Low versus, F_All and MP

In this section, we conduct a t-test to evaluate if F_Low has had significantly lower returns than F_All and MP. The hypothesis is stated below, where x denotes the difference between the absolute return of F_Low and the returns of F_All and MP respectively.

H_0: $x = 0$

H_1: $x < 0$

Table 9 – T-test statistics for F_Low versus F_All and MP considering their absolute returns.

Evaluated portfolio	**F_Low**	
Comparable	F_All	MP
Confidence interval 95%	(-infinity, -6.64)	(-infinity, 4.72)
Confidence interval 99%	(-infinity, -0.22)	(-infinity, 27.37)
P value	0.0094	0.0961
H_0	Rejected at significant level 1%	Not rejected

In table 9 we learn that the null hypothesis is rejected at a significance level of 1% for F_Low compared with F_All. This strengthens the alternative hypothesis H_1. Thus, the test shows that the absolute returns are significantly lower for F_Low in comparison with F_All. However, we could not reject the null hypothesis at any desirable level of significance when comparing the absolute return of F_Low with the returns of MP. This implies that a value investor could increase their absolute return if they rebalanced their portfolio by lowering their weight towards firms with a low F_Score. Considering the absolute returns, it does not state anything in comparison with MP.

The results from table 8 and 9 imply that the value investor can garner a higher absolute return by either decreasing his weight towards firms with low F_Scores or increasing his weight towards firms with a high F_Score, or both. Worth noting is that it is more statistically reliable, to decrease the weight towards firms with a low F_Score (significance level 1%) than increasing the weight towards firms with a high F_Score (significance level 5%). Nevertheless, the tests presented in table 8 and 9 did not take risk into account. Moreover, the returns are not risk-adjusted and thereby do not inform whether the differences in returns are due to taking more or less risk. However, one might argue that F_High could be less risky than F_Low and F_All because they are more financially stable according to their respective F_Scores. Worth to notice is that due to few data points and a highly volatile MP it is hard to prove anything. To give more reliable results, we would need to either increase the investigated time period or divided the time period into smaller intervals.

4.4 Actual returns against the expected return

In this section, we compare the actual returns of each portfolio against the expected return according to CAPM theory. First, we evaluate F_High, then F_Low and lastly F_Hedge.

4.4.1 F_High

In this section, we conduct a t-test to evaluate if F_High has had significantly higher returns than the returns it should have had according to CAPM theory.

The hypothesis is stated below, where α denotes the difference between the actual and the expected return (Er). A significantly high α can be interpreted as the portfolios Jensen's alpha, see equation (8).

H_0: $\alpha = 0$

H_1: $\alpha > 0$

Table 10 – T-test for actual return minus CAPM's expected return for the F_High portfolios.

Year	r(F_High)	Er(F_High)	Jensen's alpha (α)
2004	43.6%	16.8%	26.8%
2005	74.7%	74.9%	-0.2%
2006	38.5%	16.7%	21.8%
2007	-9.5%	2.4%	-11.9%
2008	-27.7%	-17.6%	-10.1%
2009	74.8%	8.0%	66.8%
2010	22.5%	-8.5%	31.9%
2011	-4.1%	-11.5%	7.4%
2012	20.2%	8.8%	11.4%
2013	42.5%	11.6%	30.9%
2014	58.5%	12.6%	45.9%
2015	15.0%	6.9%	8.1%
2016	62.4%	12.6%	49.8%
Mean	31.6%	10.3%	21.4%
Median	38.5%	8.8%	21.4
St. Deviation	31.2%	22.3%	21.8%
95%	(9.6, infinity)		
99%	(3.7, infinity)		
H_0	Rejected at significant level 1%		

In table 10 we learn that the null hypothesis is rejected at a significance level of 1%. This strengthens the alternative hypothesis H_1. We have thereby shown that the actual return is significantly higher than the expected for F_High. The results can be interpreted as that the portfolio has a Jensen's alpha of 9.6% at a 5% level of significance and 3.7% at a 1% level of significance. This means that F_High obtain excessive returns when using beta as risk measurement.

4.4.2 F_Low

In this section, we conduct a t-test to evaluate if F_Low has had significantly lower returns than the returns it should have had according to the CAPM theory.

The hypothesis is stated below, where α denotes the difference between the actual and the expected return. A significant low α can be interpreted as a negative Jensen's alpha, see equation 8.

H_0: $\alpha = 0$

H_1: $\alpha < 0$

Table 11 – T-test for actual return minus expected return for F_Low.

Year	r(F_Low)	Er(F_Low)	Jensen's alpha (α)
2004	20.3%	15.4%	4.9%
2005	60.1%	67.5%	-7.4%
2006	26.8%	15.3%	11.5%
2007	-16.8%	2.5%	-19.3%
2008	-15.2%	-15.5%	0.3%
2009	-26.6%	7.5%	-34.1%
2010	12.2%	-7.4%	19.6%
2011	-36.4%	-10.0%	-26.4%
2012	-23.8%	8.3%	-32.1%
2013	42.7%	10.8%	31.9%
2014	-11.4%	11.6%	-23.0%
2015	29.1%	6.5%	22.6%
2016	5.7%	11.7%	-6.0%
Mean	5.1%	9.6%	-4.4%
Median	5.7%	8.3%	-6.0%
St.Deviation	28.4%	20.0%	23.7%
95%	(-infinity, 6.3%)		
99%	(-infinity, 11.8%)		
H_0	Not rejected		

In table 11 we notice that the null hypothesis is not rejected at any desirable significant level. Subsequently, we cannot say anything regarding whether F_Low returns are lower than the expected return according to CAPM theory or not.

4.4.3 F_Hedge

In this section, we conduct a t-test to evaluate whether F_Hedge has had significantly higher returns than the returns it should have had according to the CAPM theory. The hypothesis is stated below, where α denotes the difference between the actual and the expected return. A significant high α can be interpreted as the portfolios Jensen's alpha, see equation (8).

H_0: $\alpha = 0$

H_1: $\alpha > 0$

Table 12 – T-test for actual return minus expected return for F_Hedge.

Year	r(F_Hedge)	Er(F_Hedge)	Jensen's alpha (α)
2004	23.3%	4.5%	18.8%
2005	14.6%	10.4%	4.2%
2006	11.7%	4.5%	7.2%
2007	7.3%	3.0%	4.3%
2008	-12.5%	0.9%	-13.4%
2009	101.4%	3.6%	97.8%
2010	10.3%	1.9%	8.4%
2011	32.3%	1.6%	30.7%
2012	44.0%	3.6%	40.4%
2013	-0.2%	3.9%	-4.1%
2014	69.9%	4.0%	65.9%
2015	-14.1%	3.4%	-17.5%
2016	56.7%	4.0%	52.7%
Mean	26.5%	3.8%	22.7%
Median	14.6%	3.6%	8.4%
St.Deviation	33.7%	2.3%	33.6%
95%	(6.1%, infinity)		
99%	(-2.3%, infinity)		
H_0	Rejected at significance level 5%		

In table 12 we conclude that the null hypothesis is rejected at a significance level of 5%. This strengthens the alternative hypothesis H_1. We have thereby shown that the actual return is significantly higher than the expected for F_Hedge. The results can be interpreted as that the portfolio has a Jensen's alpha of 6.1% at significance level 5%. This means that F_High obtain excessive returns when using beta as risk measurement. However, we cannot say anything regarding the difference at the more reliable significance level of 1%.

When examining Jensen's alpha (see table 10, 11 and 12), we do see that F_High and F_Hedge perform better than expected by CAPM theory. F_High shows a Jensen's alpha of 9.6% whilst F_Hedge shows a Jensen's alpha of 6.1%, both statically relevant at significant level 95 %. This implies that the portfolios perform better than MP when risk, measured as beta, is considered. Since F_Hedge consists of a 50% long position in F_High and a 50% short position in F_Low, the long position reasonably obtains the alpha. To conclude we show that a portfolio consisting of high F_Scores beat the market portfolio when adjusting for risk but not in absolute terms. However, if an investor would aim for a higher return, it would be more rational to invest in firms with a high F_Score and use leverage to obtain the desired expected return, than investing in the market.

Above reasoning experience some issues. Firstly, our market portfolio is not the real market portfolio consisting of every available asset. Therefore, our use of the CAPM does not correspond to the real CAPM, and the betas and expected returns could thereby differ from reality. Secondly is that our risk-adjusted return only takes the portfolios' sensitivity to market risk into account, i.e. systematic risk and not a firm-specific risk. Fama and French (1992) expanded CAPM to involve B/M and the size of firms. Thereby one might argue that it would be of more relevance to evaluate the returns against the returns expected by Fama and French's three-factor-model, see 2.1.5 Anomalies for joint hypothesis and 2.5 Fama and French's three-factor-model.

4.5 Beta-adjusted return: F_Low, F_High, F_Hedge vs F_All

To further evaluate if we can increase the returns of a value investor, without increasing the risk we calculated the Treynor ratio for each portfolio. In this section, we conduct a T-test to evaluate if F_High and F_Hedge (F_Low) have had significantly higher (lower) Treynor ratio than F_All. The hypothesis is stated below, where x denotes the difference in Treynor ratio between the portfolio and F_All.

H_0: $x = 0$

H_1: $x > 0$ for F_High and F_Hedge

H_1: $x < 0$ for F_Low

Table 13 – T-Test regarding beta-adjusted returns

Year	F_Low	F_High	F_Hedge	F_All
2004	48.8%	102.9%	501.2%	79.9%
2005	161.2%	181.9%	285.9%	180.7%
2006	67.1%	90.0%	214.1%	89.2%
2007	-56.1%	-31.9%	105.2%	-29.7%
2008	-51.6%	-78.0%	-384.9%	-72.4%
2009	-83.8%	182.1%	2434.4%	117.0%
2010	25.8%	49.4%	179.5%	29.3%
2011	-111.5%	-18.1%	724.0%	-29.1%
2012	-75.9%	43.5%	1013.6%	17.6%
2013	112.1%	100.1%	-80.4%	80.8%
2014	-40.8%	140.7%	1654.7%	38.8%
2015	73.6%	30.3%	-424.5%	26.6%
2016	7.5%	150.6%	1328.0%	87.8%
Mean	5.9%	72.6%	580.8%	47.4%
Median	7.5%	90.0%	285.9%	38.8%
St. deviation	83.6%	82.5%	834.2%	68.3%
P Value	0.0213*	0.0079	0.0179	-
H0	Rejected at significance level 5%	Rejected at significance level 1%	Rejected at significance level 5%	-

In table 13, we note that the null hypothesis is rejected for all three portfolios at a level of significance of both 1% and 5%. This implies that a value investor focusing on a B/M strategy could enhance his or her risk-adjusted returns by decreasing the portfolio's weight against firms with a low F_Score and increasing the weight towards those firms with a high F_Score. Together with the results presented in table 8 and table 9, we show that the value investor can create an absolute higher annual return without increasing the level of the portfolio of risk if the risk is measured as a beta with a significance level of 5%. As stated in section 3.8 Treynor ratio, the ratio adjusts for the systemic risk and not the firm-specific risk. Furthermore, the Treynor ratio is based on the asset's sensitivity to risk which according to Fama and French (1992), says little regarding the average returns for stock.

5. Conclusion

To conclude, our evaluated portfolios outperformed F_All both considering absolute and risk-adjusted returns. We thereby succeeded in showing that a value investor could increase the returns without increasing the risk by increasing (decreasing) the value portfolio weight of firms with a high (low) F_Score. When evaluating against MP, we could not prove anything regarding the absolute return, but we discovered that F_High and F_Hedge outperformed MP when returns are adjusted for risk. The excessive returns show that the use of F_Score could help separate the winners from a broader portfolio. The results thereby contradict Fama's (1970) theory of an efficient market in the semi-strong form.

Considering the use of Treynor ratio for risk-adjusting the returns and the high standard deviation amongst firms we argue that the findings should be applied on a broad portfolio rather than to determine the success for one specific firm. Although one could argue that the firms with a high F_Score should be less risky than those with a low F_Score as they are somewhat financially more stable, at least according the F_Score system.

Since our statistical analysis is not a replica of the one performed by Piotroski, it is difficult to compare the exact results, although the conclusions are similar. However, Piotroski (2000) was generally able to ascertain his results on a higher level of significance, which is in line with our expectations since his investigated sample is of a grander scale.

6. Further research

For further research, it would be of interest to focus on the accounting standards, market structure and how developed it is, and investors' view on value and growth stocks. For example, Rathjens and Schellhove's (2011) research on the U.K stock market showed an indication that an F_Score strategy with the focus on growth stock outperformed value stocks. Thus, giving a possibility at identifying the drivers of the disparity and thereby giving an increased understanding of the F_Score and how market mispricings can occur.

Further on, by only including the one-factor asset pricing model, CAPM, it gave us some limitations to our results and analysis, since conclusions regarding abnormal returns and market mispricings are residuals of the chosen model, i.e. joint hypothesis problem. Although, one could argue whether additional risk factors from an ampler model such as the three-factor model by Fama and French, could give an explanation to our alpha values and thereby changing our conclusions. If the three-factor model could change the outcome of this thesis or not, it would nonetheless add more explanatory elements to the results. Additionally, it would be of interest to see whether our conclusions would hold if the risk were measured in absolute volatility instead of the portfolios' beta.

Furthermore, for future research, it would be beneficial to ascertain one's statistical reliability by adhering to the suggestions of Barber and Lyon (1997), which emphasises the value of using several statistical methods. The problem with statistical reliability appears when finding abnormal returns. Meaning, to ensure statistical reliability one should apply several statistical methods, such as signed rank Wilcoxon-test, which is an alternative t-test when the population cannot be assumed to be normally distributed. This is to compensate the t-test, as it is based on the assumption of normality, and thereby might be a source of an error in our tests.

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