Erasmus
School of
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Bachelor Thesis Finance

Improving investment returns by identifying future winners and losers among value stocks

This paper studied, whether the use of Piotroski's F-score can increase the returns of a value investing strategy. This was done by looking at high book-to-market stocks in the period 2012-2014, ranking these based on their F-score and then comparing their cumulative returns over a period of 1, 2 and 5 years. This paper was unable to find any evidence for the F-score providing any increase of returns by selecting from among high book-to-market stocks. The result can be explained by differences in sample characteristics and the effects of the efficient market hypothesis.

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Table of Contents

1. Introduction

In the world of finance there are many different investment strategies. Fund managers, analysts and private investors all hold different beliefs surrounding how to invest and how to select stocks to buy. One of these strategies is the so-called Value investment strategy. Proposed in the 1930's by the investors Benjamin Graham and David Dodd. It is maybe best known for its current leading proponent, the renowned investor Warren Buffet. The Financial Times described it maybe the best by saying "There are many ways of measuring value and approaches to value investing, but simply put it involves unearthing under-appreciated securities trading at unfairly low prices." (Wigglesworth, 2019). This strategy calls for investors to buy companies that have good or high 'fundamentals'. Fundamentals are financial information and ratios, often found in a company's quarterly or annual statements, such as earnings-to-price (E/P), book-to-market (B/M) and current ratios. These fundamentals help with determining a specific company's value. Stocks with high fundamentals are seen as undervalued and are therefore thought to outperform the market in the long-run. This is what attracts value investors to these companies. Many different research papers like Jaffe, Keim & Westerfield, (1989) and Fama & French (1992) have argued that value stocks, also known as high book-to-market (B/M) value stocks, tend to earn higher returns than low B/M 'glamour' stocks. However, in the past decade value investing has been underperforming the market. Because of this, some in the financial world have concluded value investing to be 'dead' and a strategy of the past (Kawa, 2017). Others think it may outperform again in the future if market conditions change (Wigglesworth, 2019). This current debate about the merits of value investing is quite interesting and raises a number of questions about the strategy.

There are multiple different views on why exactly high B/M stocks outperform. One view is that the outperformance is caused by value stocks being inherently riskier and that they therefore must provide a higher return to investors as a compensation for this risk (Fama & French, 1992). Another view is that it is due to investors wrongly projecting previous bad financial performance into the future (Lakonishok, Schleifer & Vishny, 1994). This suboptimal behavior from investors causes the undervaluation of the value stocks. The undervaluation means that the stocks are relatively cheap, which in turn means they overperform in the long run. There is strong evidence that value stocks are usually firms under financial distress, having high financial leverage and uncertain future earnings (Chen & Zhang, 1998). So even though using a high B/M or value investment strategy delivers higher

returns for an investor, this possibly also increases his or her risk exposure. However, Piotroski (2000) claims he found a way of separating winner and loser value stocks. In his paper he stated that value investors can increase their average return by around 7.5% annually and simultaneously lower their risk through the selection of only the financially strong value firms. This was done by rating the firms based on 9 simple accounting fundamental ratios, afterwards combining these ratings in a so-called Piotroski- or F-score and subsequently investing in a value portfolio composed out of only the companies with high ratings.

Piotroski seems to offer a simple solution to a big problem of using a value or high B/M investing strategy. Namely selecting the value stocks which will recover from their recent bad performance and avoiding the ´value traps´, stocks which seem cheap because of their high fundamentals but who continue to perform poorly in the future. However, Piotroski researched his F-score with a dataset from 1976 to 1996. He also only looked at 1 and 2 year realized returns for his portfolio, though he did do this for 23 consecutive years, a long-term view does seem to be absent from his paper. Another point of interest is that Piotroski's paper was published 2 decades ago and has been present in the public sphere all that time. According to the efficient market hypothesis (Fama, 1970), his accounting fundamentals shouldn't work anymore because the market should have already incorporated them and made them unprofitable. For all these reasons it seems to be a useful endeavor to look into Piotroski's F-score in both a more recent dataset and over a longer time period. That is why this paper will try to answer the question: Can the use of Piotroski's F-score increase the returns of a value portfolio? This will be tested by looking at high B/M stocks from the S&P1500 Value Index and dividing these into portfolios based on Piotroski's accounting fundamental ratios. Portfolios will be made for multiple years. The data used for is sourced from Compustat and CRSP. Each of the high B/M stocks will receive a certain score based on Piotroski's ratios. For each of the 9 individual fundamental ratios a stock can get either a 1 or a 0. This results in a total score which ranges from 0 to 9, with 9 being the best score. The stocks with the highest scores in a certain year will be put in a portfolio as will the stocks with the worst scores.

The realized return on these portfolios will then be compared to each other and to a measure for the return of the general stock market. The returns will be compared for 1, 2 and 5 years after portfolio formation. Comparing the different portfolios allows for determining whether Piotroski's ratios can identify good value stocks in the current market. According to the efficient market hypothesis Piotroski's accounting fundamentals shouldn't be able to produce an excess return since they have been in the public domain for so long. Combining this with the fact that value investing seems to have been underperforming since the 2008 financial crisis (Lauricella & Lynch, 2019). I don't expect the use of Piotroski's F-score to be able to increase returns for a high B/M/value portfolio.

The structure of this paper will look as follows. First in the Literature Review we will take a look at the theoretical underpinnings of value investing, the empirical results surrounding the subject and how Piotroski's value strategy fits into it. Thereafter, in the methodology section of the paper, the data-collection and research methods will be described. In the results section we will talk about the research results. And lastly, in the conclusion section, a short summary will be given as well as a discussion about possible defects in Piotroski´s (2000) paper and potential future research about this subject.

2. Literature Review

2.1 Value Investing

In this paper we will be looking at a particular high book-to-market (B/M) ratio investment strategy. This strategy has been developed by Piotroski (2000), and tries to identify winners and losers among high B/M or 'value' stocks. This method is one in a long line of attempts by both academics and professionals to develop a method that can consistently earn higher returns than the market by selecting certain stocks thought to be able to outperform the market. For example, a similar method was looked at by Chan (1988) the so-called 'Contrarian Investment Strategy', is a strategy based on buying stocks that recently had large negative returns and selling stocks which have had recent large positive returns. This method was based on the Overreaction Hypothesis (De Bondt & Thaler, 1985), which stated that people tend to overreact to unexpected and dramatic news or events. This leads to stocks having too high of a price after positive news and too low a price after recent negative news.

The contrarian investment strategy tries to use this inefficiency to produce a return higher than the general stock market. This idea of (temporary) market inefficiencies and mispricing also forms the basis for the existence of value and glamour stocks.

Just like the contrarian Investment Strategy, the high B/M investment strategy tries to make use of supposed inefficiencies in the market to try to generate higher returns than the general stock market. It does this by investing in a certain category of stocks with high book to market ratios. This ratio is a measure for the amount of assets a company has versus its market capitalization. The high B/M ratio is one of a number of different fundamental ratios that are used to value stocks. Other often used fundamental metrics are the earnings/price (E/P), dividend yield (D/P) and cashflow/price (CF/P) ratios (Lakonishok, Schleifer & Vishny, 1994). These fundamentals are all used to identify undervalued stocks which should outperform the market in the long-run. These undervalued stocks, called value stocks, are thought to have an underestimated earnings potential and temporarily depressed prices due to for example, recent bad news or a lack of coverage by analysts (Doukas, Kim & Pantzalis, 2008). The idea is that in the long-run the market will recognize that these stocks have been priced too low and the value stocks will rise in price. The opposite of value stocks are called 'glamour' or 'growth' stocks. These glamour stocks are often more heavily covered by analysts and have a high earnings growth (Lakonishok, Schleifer & Vishny, 1994). Investors have developed many different investment strategies based on these two types of stocks, and although these are both interesting investing methods, we will be focusing on value investing since Piotroski developed his specific investing strategy from it.

2.2 Empirical bases of Value Investing

Many different papers have examined whether value stocks overperform compared to growth stocks. The general consensus of most of these papers seems to be that value stocks indeed provide higher returns. Using data from several US stock indices over the period of 1962 to 1990 Fama & French (1992) found that, when controlling for size, there was a strong positive correlation between the book-to-market ratio and the average return. On average the high B/M portfolio outperformed the low B/M portfolio by about 0.99% per month over the whole period. Lakonishok, Shleifer & Vishny (1994) also found that in the period of 1968 to 1990 portfolios of value stocks outperformed growth stock portfolios in the US stock market by an average of about 10% - 11% per year. Both of these papers already seem to indicate that

value investing outperforms growth investing in the US stock market. There is evidence that this is not only a US phenomenon, but that it is also the case internationally. In their paper Capaul, Rowley & Sharpe (1993) compared the returns on portfolios of growth and value stocks for six different countries over a period of 11 years, from 1981 to 1992. In their paper value stocks were defined as stocks with a high book-to-market ratio and growth stocks as stocks with a low book-to-market ratio.
They found that value stocks outperform growth stocks on average in each of the 6 different countries, even after adjusting the returns for risk. Other more recent research by Fama & French (2002) also looked into international performance of value stocks. They looked at the returns of value and growth stocks over a period of 20 years at the US stock market and stock markets of 12 other major countries. They found that internationally value stocks outperformed growth stocks in 12 of the 13 markets by about 7.68% annually. All this evidence seems to indicate that there is a clear value premium present in the (global) stock market. However, even though there is consensus on the fact that value stocks outperform, the reason for the existence of this outperformance is still being debated.

It is not entirely agreed upon why exactly value stocks overperform, the first view is that due to market inefficiency, value stocks are underpriced compared to their true value and conversely growth stocks are overpriced compared to their true value. The second view is that value stocks have been correctly priced by the market because they are inherently riskier than other stocks. This means that even though value stocks may offer a higher return, this higher return is balanced out by the fact that they also have a higher risk attached to them. Lakonishok, Schleifer & Vishny (1994) argue that value stocks are underpriced relative to their risk and return because of behavioral and institutional reasons. They found evidence that suggests that investors wrongly base expected future earnings growth on past earnings growth and are often "putting excessive weight on recent past history" (Lakonishok, Schleifer & Vishny, 1994, p. 1575). These 'expectational errors' as they call them were further looked into by Porta, Lakonishok, Schleifer & Vishny (1997). In this article they looked into the event returns around earnings announcements and found that the expectational errors about future earnings can explain a big part of the value stock outperformance. The differences in earnings announcement return between value and stocks accounted for as much as 25%-30% of the annual return overperformance of value stock. Scott & Miller (1997) also did research on this subject and supports this view. On the other side of the argument, Fama & French (1993,1995,1996) have argued in multiple papers that the overperformance of value stocks

can be explained mainly by the fact that these stocks carry more risk with them. Consequently, the higher return of value stocks is just a compensation for risk which isn't incorporated into the CAPM. They regard firms with high B/M ratios as being financially distressed firms. Campbell, Hilscher & Szilagyi (2010) also argued that the value effect is a compensation for the risks of financial distress and not due to the market underpricing these stocks. This conflicting evidence on the cause of the value premium makes it more difficult to construct a value investing strategy that will consistently make it possible to outperform.

2.3 Piotroski's Investing Strategy

Often, when researching value investing, so-called 'simple value strategies' are used. For example, in their research Lakonishok, Schleifer & Vishny (1994) measured value overperformance by constructing simple portfolios based on 5 pairs of different measures of value. Because we know that value stocks do tend to outperform both growth stocks and the general market (Lakonishok, Schleifer & Vishny, 1994; Fama & French 1995) constructing a portfolio based on these simple value measures like B/M, E/P etcetera will probably generate outperformance. However, because the reason why value stocks overperform is still unknown this could be a risky action. If, like Fama & French (1995,1996) claim, value stocks are inherently riskier because of financial distress, then a value portfolio also has more risk connected to it. The general idea of Piotroski's strategy (2000) is to use nine different fundamental ratios and indicators from historical financial statements to try and remove the stocks with the most downside risk and select only the financially strong companies from among a portfolio of high B/M (value) stocks. By removing the 'weak' value stocks which are possibly financially distressed and investing only in a portfolio of the ´strong´ value stocks which have wrongly depressed prices due to for example temporary setbacks, recent bad news or a lack of analyst coverage one should be able to improve the returns earned by value investing and reduce the downside risks possibly attached to it. By using this fundamental information, and using it to select these only the ´strong' value stocks from among a broad range of value stocks from 1976 - 1996, Piotroski showed that a high B/M (value) investor could increase the returns on his portfolio by around 7.5% annually. Considering that the average market return of the S&P500 over the past 50 years has been roughly 8% annually (Maverick, 2020) this would be a very useful stock picking method indeed. However, considering that the weak form of the efficient market hypothesis (Fama, 1970) predicts that any known historic knowledge will be assimilated by the market in the

formation of stock prices, the use of Piotroski's fundamentals should not be able to generate any overperformance nowadays. This would certainly be true, since any investing strategy that could reliably improve returns by 7.5% would be a much covered and used one. Another point to take into account is that the investing climate was very different around the time Piotroski did his research. The 1980's and 1990's were a high point for value investing as a whole, while in the current climate, value investing has been underperforming the market in recent years (Markowicz, 2018). Considering all this, it remains to be seen if Piotroski's method is still able to outperform. That is why we will be trying to answer the following hypothesis:

Hypothesis: The use of Piotroski's F-score can increase the returns of a value portfolio.

Answering this hypothesis will help us determine if Piotroski´s accounting fundamentals are a useful way to improve investment returns. In the next part we will show how this hypothesis will be answered, discuss the relevant variables and see which datasets will be used.

3. Data & Methodology

3.1 Data

As a data source I will be using the combined Compustat & CRSP database available from the Wharton Research Database. This combined data source combines the security-level data from the CRSP database with company-level data included in the Compustat database. The CRSP data contains security level descriptive information and market data of more than 32.000 inactive and active companies from the NYSE, NYSE American, Nasdaq and NYSE Arca exchanges. The Compustat data contains annual and quarterly balance sheets, income statements and other data times for thousands of active and inactive companies.

To be easily able to select firms from among a high B/M ratio portfolio, the 200 highest B/M companies were selected each year from the S&P1500 value index over a 3-year period from 2012 to 2014. After removing the firms for which financial data was missing, 211 companies were left in the sample. On these companies Piotroski's Fundamental-score, or F-score, was used to divide up the high B/M stocks into different portfolio's based on their ranking. Piotroski originally divided the stocks from his sample in the 'High' portfolio if they had a F-

score of 8 or 9, and placed the stocks with a F-score of 0 or 1 into the ‘Low’ portfolio. Because using this method would produce portfolios with too few stocks in them a new way of sorting the stocks into their portfolios was devised. If a company had a total score of 6 to 9 it was placed in the ‘high’ portfolio, if it had a score of 4 or less it was placed in the ‘low’ portfolio. These portfolios were equally weighted when formed, initially causing every firm to make up the same percentage of the portfolio. The weight of individual stocks could change over time during the research period, because the portfolios were not rebalanced. Though the way of selecting stocks for the ´High´ and ´Low´ portfolio is different in this paper as compared to Piotroski´s paper, the research is fundamentally still comparable. Since the main aim of both this paper and Piotroski´s is still to test whether Piotroski´s F-score can improve Value investing returns.

After portfolio formation the corresponding returns of the companies were added to the dataset. The firm-specific and portfolio returns are measured as one-, two- and five-year buy-and-hold cumulative returns over a total period of 2013 to 2020. For purposes of calculating the returns of the firms and portfolios, the ‘buy’ date of the shares was the first trading day of the year after the F-score was calculated. Meaning that for companies which were scored based on financial data from 2011, the ‘buy’ date of the stock is on the first trading day of 2012. For firms which were delisted from the index during the research period because of either buy-outs, acquisitions or mergers, return data was added manually. For firms which were delisted because of bankruptcy or an inability to meet NYSE listing standards a total return of -100% for the firm was assumed for any date within the research period following the delisting.

To help identify the financial and market characteristics of the companies a further variable was added. The market-value-of-equity (MVE) variable, calculated as the number of shares times the share-price. This variable is used to see if the size of the firms has any influence on the performance of the value stocks. Numerous papers since have indicated the existence of a size effect in stock returns, where small firms earn higher stock returns than big firms. Some of the earliest evidence for the existence of this anomaly was found by Banz (1981), however even in more recent papers there still seems to be proof that the size effect plays a role in stock returns (van Dijk, 2011) The second variable to be added was the momentum variable, this variable is measured as the firm-specific 6-month return before portfolio formation.

3.2 Methodology

Using the following linear model, the total score for the high B/M stocks was calculated based on Piotroski's accounting fundamentals.

Fundamental Score = ROA + CFO + ΔROA + Accrual + Accrual + ΔLEVER + ΔLIQUID + EQ_OFFER + ΔMARGIN + ΔTURN

The dependent variable Fundamental Score is a binary variable ranging from 0 to 9. The 9 independent variables are all binary and can either be 0 or 1. ROA is the return on assets variable and is calculated by dividing current year net income divided by total assets. With 'current year' meaning the year in which the stock is rated and added to a portfolio. CFO stands for cash flow from operations, this variable is calculated by dividing current year CFO by total assets. The ΔROA variable measures the change in return on assets from the previous to current year. Accrual stands for the current net income minus CFO divided by total assets. The ΔLEVER independent variable measures the change in leverage, calculated as long-term debt to total assets, from the previous year to the current year. EQ_Offer indicates if the company issued any common equity in the previous year. The variable ΔMARGIN measures change in the company's current gross margin ratio, calculated as the gross margin divided by sales. ΔTURN is a variable used to measure turnover, and is calculated by dividing sales on total assets. The description of all the dependent variables can also be found in table 3.1.

Table 3.1: Description of Piotroski's accounting fundamental variables

Variable name	Definition
ROA	Return on assets. Current year net income divided by beginning of the year total assets. If ROA is positive it gets a score of 1, if it is negative it gets a 0.
CFO	Cash flow from operations. Current year Cash generated from operating activities divided by beginning of the year total assets. If positive it gets a score of 1, if negative 0.

ΔROA	Change in the return on assets. Calculated as this year's ROA minus the previous year's ROA. If a positive number it gives a score of 1, if negative a score of 0.
Accrual	Current year's net income less cash flow from operations divided by the beginning of the year total assets. If positive (CFO>ROA) it gets a score of 1, otherwise 0.
ΔLEVER	Change in Leverage. Change in ratio of total long-term debt to average total assets. An increase in leverage gives a score of 0, a decrease gives a 1.
ΔLIQUID	Change in Liquidity. This is the change in the current ratio (current assets/current liabilities) when comparing t=0 and t=-1. Gives a score of 1 if positive, 0 if negative.
EQ_OFFER	Equity offering. Measures if the company issued common equity in the period t=-1. Gets a score of 1 if no equity was issued and 0 when the company did offer stock.
ΔMARGIN	Firms current gross margin ratio (total sales minus cost of goods sold divided by total sales) minus the prior year's gross margin ratio. Gets a score of 1 if positive, otherwise a 0.
ΔTURN	Change in asset turnover ratio: Current year asset turnover ratio, measured as total sales divided by beginning of the year total assets, minus last year's asset turnover ratio. If positive 1, if negative 0.

The ´High´ portfolio and ´Low´ portfolio were compared using the two-way test for mean difference. This test tries to identify whether there is a significant difference in the mean between two different groups using the standard deviation. Because the standard deviations of the portfolios were dissimilar, the unequal variances version of the two-way test for mean difference was used. The test was Upper One-Sided, testing whether the 'High' portfolio had a bigger average return than the 'Low' portfolio. It had the following alternative hypothesis:

$H_{\alpha}: \mu_1 > \mu_2$

And rejected the null hypothesis in favor of the alternative hypothesis when:

$t > t_{critical}$

The t-statistic of the two-way test for mean difference with unequal variances was calculated using the following formula:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

4. Results

4.1 Sample Characteristics

In table 4.1 the descriptive financial characteristics of the entire high book-to-market sample can be found. As can be seen in table 4.1 the average (median) market capitalization of the high book-to-market sample is 10825.08 (2060.924) million dollars. When comparing this number to the average (median) value of assets of the firms of 10153.96 (2077.651) million dollars, it can be seen that the average (median) book-to-market ratio of 1.10 (0.98) reflects both these numbers with some accuracy. Other interesting statistics are the negative average return on assets (ROA) of -0.001, the negative change in the average return on assets of -0.009 and the negative change in liquidity of -0.114. All these negative averages can be interpreted as an indication of the reason for the underperformance of these stocks and their correspondingly high B/M ratios. For example, Fama & French (1995) found that high B/M ratios correspond with persistent poor earnings. In the last column the percentage of firms with a positive signal for the specific variable can be found. This indicates the percentage of

firms which received a 1 (a positive signal) instead of a 0 counting towards their specific F-score for the variable mentioned in the left-hand side column. For example, when looking at the ROA variable 66.83% of all the firms had a 1 counting towards their total F-score for this variable.

Table 4.1: Financial Characteristics of the High Book-to-Market sample (211 observations between 2012-2014)

Variable	Mean	Median	Standard Deviation	Percentage with Positive Signal[1]
MVE[2]	10825.08	2060.92	20946.14	n/a
Assets	10153.96	2077.65	18518.13	n/a
B/M	1.1035	0.9804	0.3920	n/a
ROA	-0.0019	0.0197	0.0790	0.6683
CFO	0.0697	0.0681	0.0588	0.9194
ΔROA	-0.0095	-0.0049	0.0793	0.4171
Accrual	0.0716	0.0546	0.0722	0.9242
ΔLever[3]	-0.0044	0	0.0612	0.4550
ΔLiquidity	-0.1143	-0.0477	1.2621	0.4408
ΔMargin	0.0021	-0.0024	0.3242	0.4739
ΔTurnover	0.0017	-0.0074	0.2643	0.4692

[1]: Percentage of firms which get a 1 counting towards the F-score for the corresponding variable (in other words a 'positive' signal).
[2]: Both market-value-of-equity (MVE) and Assets are in millions, B/M is in decimal numbers. The remaining variables are in percentages.
[3]: A negative coefficient for change in leverage variable is seen as a positive signal, since it means that long-term debt compared to total assets has decreased.

Table 4.2 contains the yearly cumulative buy-and-hold returns for the entire high book-to-market sample. The one-, two- and five-year periods all show strong average returns, with the one-year return being 0.1509, the average two-year return being 0.2745 and the five-year cumulative return being 0.4202. Though the high standard deviations do indicate that the returns are quite volatile. Another point of interest is that for all three periods more than 60% of the firms show positive returns, these numbers being quite similar to the percentage of positive returns in Piotroski's paper (2000). The returns themselves, however, are quite a bit

lower in this sample compared to Piotroski. Piotroski found one- and two-year average cumulative returns of 0.239 and 0.479 respectively.

Table 4.2: Yearly cumulative buy-and-hold returns for entire sample

Variable	Mean	Median	Standard Deviation	Percentage of firms with Positive Returns
One year returns	0.1509	0.1559	0.5002	0.6446
Two year returns	0.2745	0.1428	0.8839	0.6019
Five year returns	0.4202	0.2430	1.2311	0.6209

4.2 'High' & 'Low' Portfolio returns

After dividing the sample up into the 'High' and 'Low' portfolios the average one-, two- and five-year cumulative returns and standard deviations were calculated for each of the portfolios. These numbers are represented in Table 4.3. In contradiction to expectations the 'Low' portfolio outperforms the 'High' portfolio in each individual year with quite some margin. In the first year the 'Low' portfolio outperformed by 0.1796. In the second year this increases to a 0.4345 outperformance. In year 5 the outperformance of the 'Low' portfolio decreased somewhat, but it is still considerable at 0.3410. The 'High' portfolio also earns lower returns than the average Market return every year of the holding period.

Table 4.3 High & Low portfolio cumulative average returns

Variable	Mean One-year Return (SD[1])	Mean Two-year Return (SD)	Mean Five-year Return (SD)	Sample Size
High Portfolio	0.0811 (0.3754)	0.1501 (0.6141)	0.3485 (1.1214)	100
Low Portfolio	0.2597 (0.6207)	0.5846 (1.2311)	0.6895 (1.4460)	61
High-Low difference	-0.1786	-0.4345	-0.3410	n/a
Market Return (S&P500)	0.1332	0.2138	0.6000	n/a

[1]:SD: Standard Deviation, is given between brackets

However, with these higher returns from the ‘Low’ portfolio the standard deviation is also increased substantially. This means that even though the ‘Low’ portfolio outperforms the ‘High’ portfolio it also has a significantly higher risk attached to it. Because the standard deviation is so large it might still be interesting to compare the means of these two portfolios. As Table 4.4 shows however, the chance that the ‘High’ portfolio can outperform the ‘Low’ portfolio is statistically near zero. In years one and two the p-value when testing whether the high-portfolio has a higher return than the ‘Low’ portfolio is above 0.99. For year five it is a little lower at 0.9409, but still very far from significant. This means we fail to reject the hypothesis of the test.

Table 4.4: Test for mean difference between High and Low portfolios

Variable	One-year Return	Two-year Return	Five-year Return
High-Low Mean[1]	-0.1786	-0.4346	-0.3411
P-Value (t-statistic)	0.9974 (-2.0315)	0.9940 (-2.5689)	0.9409 (-1.5758)

[1]: Ha: diff > 0, Pr (T > t)

4.3 Return Differences between F-scores

Since we can find no evidence for the ‘High’ portfolio outperforming the ‘Low’ portfolio we should take a look at the underlying F-scored firms which make up these portfolios. In table 4.7 every F-score rank is shown with corresponding one-, two- and five-year returns. This table again shows that the higher F-scored firms perform worse on average than the lower F-scores. Especially firms with a F-score of 3 perform very well each period, with the one-, two- and five-year cumulative returns being 0.4319, 0.9748 and 1.1143 respectively. The firms with the highest F-score of 9 performed the worst, with negative returns for each period. Though this may not be entirely representable since it has a very small sample size of 2. But the other ‘high’ F-scores, 7 and 8, also perform rather poorly when compared to the lower F-scores.

Table 4.5 Average cumulative returns per F-Score

Piotroski F-Score Total	Mean One-year Return (SD[1])	Mean Two-year Return (SD)	Mean Five-year Return (SD)	Sample Size
0	n/a (n/a)	n/a (n/a)	n/a (n/a)	0
1	n/a (n/a)	n/a (n/a)	n/a (n/a)	0
2	0.0551 (0.6826)	1.0472 (2.2867)	0.8104 (2.0650)	5
3	0.4319 (0.9743)	0.9748 (1.8154)	1.1143 (1.8813)	12
4	0.2359 (0.4876)	0.4257 (0.8318)	0.5600 (1.2435)	44
5	0.1580 (0.5392)	0.1448 (0.7499)	0.2352 (1.1218)	50
6	0.0714 (0.3370)	0.2025 (0.6662)	0.5588 (1.3740)	49
7	0.0478 (0.4229)	0.0448 (0.5808)	0.1222 (0.8470)	35
8	0.2274 (0.3379)	0.3025 (0.4728)	0.2441 (0.5439)	14
9	-0.1234 (0.7158)	-0.3570 (0.5465)	-0.1160 (1.0437)	2

[1]:SD: Standard Deviation, is given between brackets
The means and standard deviations are all in percentage points

4.4 Portfolio Fundamental Characteristics

After the finding that the 'High' portfolio is unable to outperform the 'Low' portfolio it is important that we take a look at the fundamental characteristics of both portfolios to determine whether there are any significant differences which could explain this result. When comparing the financial characteristics from the 'High' portfolio in Table 4.5 with the financial characteristics from the 'Low' portfolio in Table 4.6, a few significant differences stand out. For example, though the means of the size characteristics variables MVE and Assets are comparable between the two portfolios the median is substantially lower for the 'Low' portfolio. With the 'High' portfolio MVE (Assets) median being 4007.78 (4172.81) million dollars and the 'Low' portfolio MVE (Assets) median being 1547.14 (1776.33) million dollars. This difference between the medians of both portfolios indicates that the 'Low' portfolio is made up by a large number of smaller companies. From earlier papers we know the size effect has a significant effect on stock returns (van Dijk, 2011). Piotroski (2000) himself found in his own paper that "the above-market returns earned by a generic high BM portfolio are concentrated in smaller companies" (p. 21). An even more noticeable difference can be found in the variables which measure profitability. Here the average ROA

of the ‘High’ portfolio is 0.0245 with 88% of firms having a positive signal. The average ROA of the ‘Low’ portfolio is -0.0349 with only 39.34% of firms having a positive signal. The ΔROA variable shows a similar difference between the two portfolios, with the most eye-catching aspect being that only 9.84% of ‘Low’ portfolio firms report a positive signal for the ΔROA variable. When looking at the ΔLiquidity, ΔMargin and ΔTurnover variables the ‘Low’ portfolio again shows negative averages and a low percentage of firms with positive signals, while the ‘High’ portfolio has positive means for all these variables and a large number of the firms reporting positive signals.

Table 4.6: Financial Characteristics of the ‘High’ Portfolio (100 observations between 2012-2014)

Variable[2]	Mean	Median	Standard Deviation	Percentage with Positive Signal[1]
MVE	12781.08	4007.78	20482.31	n/a
Assets	12084.28	4127.81	18179.47	n/a
B/M	1.0284	0.9570	0.2808	n/a
ROA	0.0245	0.0282	0.0484	0.8800
CFO	0.0900	0.0792	0.0504	1
ΔROA	0.0155	0.0060	0.0760	0.6400
Accrual	0.0655	0.0537	0.0576	0.9600
ΔLever[3]	-0.0116	-0.0033	0.0590	0.7200
ΔLiquidity	0.2530	0.0802	1.1438	0.6100
ΔMargin	0.0731	0.0135	0.3977	0.7200
ΔTurnover	0.0231	0.0058	0.3566	0.5500

[1]: Percentage of firms which get a 1 counting towards the total F-score for the corresponding variable.
[2]: Both market-value-of-equity (MVE) and Assets are in millions, B/M is in decimal numbers. The remaining variables are in percentages.
[3]: A negative coefficient for the change in leverage variable is seen as a positive signal, since it means that long-term debt compared to total assets has decreased.

Table 4.7: Financial Characteristics of the 'Low' Portfolio (61 observations between 2012-2014)

Variable[2]	Mean	Median	Standard Deviation	Percentage with Positive Signal[1]
MVE	12284.63	1547.14	25956.42	n/a
Assets	11396.14	1776.33	23302.92	n/a
B/M	1.1378	0.9804	0.4160	n/a
ROA	-0.0349	-0.0104	0.0913	0.3934
CFO	0.0500	0.0616	0.0700	0.8033
ΔROA	-0.0471	-0.0272	0.0656	0.0984
Accrual	0.0849	0.0690	0.0791	0.9016
ΔLever[3]	0.0094	0.0067	0.0603	0.4262
ΔLiquidity	-0.2241	-0.1332	0.6235	0.2623
ΔMargin	-0.1032	-0.02467	0.2473	0.1475
ΔTurnover	-0.0325	-0.0270	0.1367	0.2951

[1]: Percentage of firms which get a 1 counting towards the F-score for the corresponding variable.
[2]: Both market-value-of-equity (MVE) and Assets are in millions, B/M is in decimal numbers. The remaining variables are in percentages.
[3]: A negative coefficient for the change in leverage variable is seen as a positive signal, since it means that long-term debt compared to total assets has decreased.

While adding in the returns of the firms to the dataset it was found that many firms had delisted from the NYSE during the research period, the reasons for the delistings were varied. While a small number of the firms went bankrupt or failed to meet NYSE listing requirements, most firms were delisted because they were acquired by or merged with another firm. Table 4.8 provides information about these delistings. When looking at the end of the five-year period out of a total of 211 firms, 44 had been delisted. Now, while a number of bankruptcies or acquisitions might be expected for firms which are financially distressed and/or are trading close to or below their book-value the total number seems relatively high. Delisted firms make up 20.85 percent of the entire sample, with most of these delistings being either mergers or acquisitions. This is a significant difference with Piotroski's sample (2000), where only 4.27% of the total number firms were delisted. This difference can be partially explained by the fact that there has been significant merger and acquisition activity

during the research period of 2013-2020, while during Piotroski's research period of 1976 to 1996 there were much less mergers and acquisitions (M&A US, 2019).

Table 4.8: Number of Firms delisted after five years

Variable	Number of Mergers/Acquisitions	Number of Bankruptcies/Failures to meet Requirements	Total Delisted Firms	Number of Firms	Percentage of Delisted Firms
'High' Portfolio	14	0	14	100	0.1400
'Low' Portfolio	12	2	14	61	0.2295
Entire Sample	37	7	44	211	0.2085

5. Conclusion & Discussion

This paper tried to test whether using Piotroski's F-score (Piotroski, 2000) would increase the returns earned on a high B/M (value) portfolio. During the 2013-2020 period looked at in this paper, no evidence could be found to support this hypothesis. Using the F-score to sub-divide the high scoring value firms and low scoring value firms into a 'High' and 'Low' portfolio, the one-, two- and five-year cumulative buy-and-hold returns of these portfolios were compared. The 'Low' portfolio consistently had higher average returns than the 'High' portfolio in every time period. When the average returns of the individual F-score ranks were compared the same picture appeared. High F-score firms generally performed worse than Low F-score firms. The opposing results found between this paper and Piotroski's paper (2000) may be explained by a number of differences in the respective samples. Another explanation may lie in the efficient market hypothesis (Fama, 1970) reducing the F-score's positive effect on returns over time. Firms in the sample from this paper where on average larger, had a lower B/M. Especially the differences in market capitalization would have led to the size effect (Banz, 1981; van Dijk, 2011) causing a major difference in returns. This paper does not mean to say that the Piotroski's F-score and its underlying fundamental variables are proven to be unreliable, only that there seems to be no evidence to support the notion that the F-score is consistently able to increase the returns of value investors by 7.5% annually.

There are a number of limitations that impact the usefulness of this paper. The most important of these is the relatively low sample size of 211 firms. This small sample size has caused there to be too few firms in some of the F-score rankings, with the F-scores of 0 and 1 containing no firms. This in turn caused Piotroski's way of dividing the firms in portfolios to be untenable. Another possible limitation is the time-frame. Because the research period only ran from 2013 to early 2020 there was no chance to see the effects of the business cycle on the validity of the F-score. Possible future research into this subject should at least take into account the limitations mentioned above. But it could also look into how each specific F-score fundamental variable effects long-term returns for the high B/M firms. Another possibility would be to see how the F-score performs when looking at 10-, 15- or even 20-year returns. Such a long-term viewpoint would certainly provide for interesting and useful research.

6. Bibliography

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