Evaluating the Effectiveness of the Piotroski F_Score Methodology within the South African Market

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DECLARATION

The research dissertation at hand is presented for the approval of the University of Cape Town's Senate in fulfilment of part of the requirements for the degree of Master of Commerce specialising in Financial Management in approved courses and a minor dissertation.

I hereby declare that I have read and understood the regulations governing the submission of Master of Commerce dissertations, including those relating to length and plagiarism, as contained in the rules of the University, and that this dissertation conforms to those regulations.

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ABSTRACT

This study examines whether the Piotroski F_Score (2000) investment strategy framework is able to be replicated within the South African context. Prior work by Atwood (2012) concluded that whilst a High F_Score portfolio was able to outperform a Low F_Score portfolio, it was however not statistically significant over the selected period. This study expands prior research and provides empirical evidence that a modified High F_Score investment strategy is able to outperform both the market and a Low F_Score portfolio over the medium and long-term. These results suggest that it is possible to use accounting-based information to construct a portfolio which is able to shift an investor's distribution of returns, and thereby generating positive abnormal returns within the South African context. Following on from these conclusions, this study further examines whether there is any evidence supporting the use of the Piotroski F_Score strategy by South African equity fund managers. The findings indicate that, on aggregate, South African equity managers do not tilt their portfolios towards firms with Higher F_Scores, which is surprising given the superior returns generated by the F_Score strategy over the long-term.

KEYWORDS: Piotroski, F_Score, Future Stock Returns, Fundamental Analysis, Market Efficiency

1. INTRODUCTION

The Piotroski F_Score investment strategy is one which has gained substantial international interest over the last decade, following the original research paper prepared by Joseph Piotroski (Piotroski, 2000), a finance professor at Chicago University's Business School at the time. The premise of the F_Score was to develop an investment strategy that made use of easily accessible and publicly available data, in order to differentiate between financially improving and deteriorating firms. The F_Score's aim is to identify firms which are improving financially, as evaluated on a number of binary measures, and therefore whose stock price will, on average, outperform the market over the long-term.

This study's aim is to examine whether the F_Score has any practical application within the South African FTSE/JSE. Prior work prepared by Atwood (2012) suggests that a full replication of the F_Score methodology as per Piotroski (2002, 2002) was not statistically significant on the FTSE/JSE over the period 2005 to 2010. Atwood was however able, to illustrate the fact that whilst the returns achieved were not necessarily statistically significant, the high F_Score long-only portfolio was able to generate annualised returns greater than that of the market and the low F_Score portfolios, for the period selected on a total return basis.

I have decided to readdress whether the Piotroski F_Score can be used on the FTSE/JSE in order to generate abnormal returns above the market. The analysis period for this study has been increased from January 2004 to December 2012 with the F_Score investment strategy involving quarterly rebalancing and an omission of the use of the book-market (BM) ratio as a screening criterion. The quarterly rebalancing approach is consistent to recent work prepared by Zhou and Tice (2011) whereby the study found that the F_Score was also statistically significant over rolling quarterly holding periods. Additionally, the study does not include the BM ratio as a screening criterion used in the portfolio construction process. This methodology was adopted as a result of two important considerations. The first was that the Zhou and Tice (2011) study presented findings that indicated that the high book-market ratio criteria was not a critical component in selecting high F_Score firms which would subsequently outperform the market. And secondly, the South African FTSE/JSE is heavily dominated by large-cap stocks, which results in the share universe of available liquid stocks on the FTSE/JSE being significantly smaller in comparison to Europe or North America. The result of the inherently smaller South African investment universe has meant that the relaxation of the high BM selection criteria was critical in allowing for the high F_Score strategy to be examined without having to contend with overly concentrated portfolios which would not practically be followed by both individual and institutional investors alike.

The results of the modified F_Score investment strategy employed in this study, indicated that a high F_Score portfolio consistently outperforms both a low F_Score portfolio and overall market on a quarterly total return basis. Over the period January 2004 to December 2012, the high F_Score portfolio generated an annualised return of 42.9% which outperformed the low F_Score and market portfolios by 22.6% and 13.0% respectively. Moreover, the quarterly return of the high F_Score long-only portfolio outperformed the market portfolio in 74% of all observations, and as such was proven to have generated abnormal returns above the market and low F_Score portfolios on a market-adjusted return basis. The above results were consistent with a similar study which was performed using a rolling 12-month holding period with annual rebalancing. Moreover the effectiveness of the F_Score was again confirmed even after controlling for firm size. These results, for the effectiveness of the F_Score investment strategy on the FTSE/JSE, were moreover recently confirmed by Hyde (2013), whereby it was found that the F_Score methodology was statistically significant for South Africa as well as other emerging markets.

The results of the various tests used to establish whether the F_Score methodology can be effectively used as an investment strategy in order to generate excess market returns indicates that the strategy is statistically significant on the FTSE/JSE and offers investors and opportunity to generate abnormal returns. Even though the methodology used in this study could be in theory carried out by individual investors, one would primarily expect that if any investors used the strategy in practice, that it would be sophisticated institutional investors. One would expect that given the presence of an investment methodology, that has been proven on a number of developed equity markets to outperform market returns over the long-term, that it would be adopted by sophisticated investors looking to exploit the opportunity. In this study I look to use a similar methodology to that used by Zhou and Tice in an attempt to establish whether there is relationship between equity unit trust managers Fund_Scores and their subsequent returns. The results of the analysis visibly indicates that the relationship between equity manager returns and their respective returns is weak at best and that equity managers do not slant their portfolios toward high F_Score firms. Interestingly, a relationship was uncovered when the Fund_Scores of the various equity managers was compared not on an absolute basis, but rather a relative basis. It clearly indicated that the top quartile portfolio (15.2%) of unit trust equity managers, as ranked quarterly by Fund_Score, outperformed both the average manager universe (12.3%) and the bottom quartile (9.4%) portfolio for the selected period.

2. LITERATURE REVIEW

2.1. Prior research supporting the use of fundamental signals to establish firm strength.

The Piotroski F_Score has been extensively reviewed and tested throughout developed markets around the world in an attempt to establish its effectiveness as a screening tool which can be used to generate abnormal returns above the market. Joseph Piotroski (2000) developed the F_Score investment strategy with the simple intention of using publicly available accounting-based firm information to distinguish between strong and weak firms. Intuitively, the stronger firms are assumed to achieve greater future stock returns relative to the weaker firms as classified by the Piotroski F_Score. Fundamentally this strategy relies on the F_Score method's ability to predict future firm performance, on a relative basis, along with the market's inability to recognize these predictable return patterns.

The underpinnings of the Piotroski work, is a study by Frankel and Lee (1998) whereby the authors' attempted to "separate winners from losers" through a process of establishing a firm's intrinsic value relative to actual market pricing. More specifically, Frankel and Lee attempted to determine whether a stock was over/under-valued by using a simple accounting-based firm valuation in conjunction with analyst consensus firm forecasts. The approach when applied to constructing a portfolio delivered significant excess returns over the market assuming a three year holding period. Similarly, Ou and Penman (1989) also managed to illustrate the effectiveness of historical account-based information in predicting future firm performance. Both of the above mentioned studies however have significant practical shortfalls, along with other similar studies, in that the methodology used to derive the results are very complex and require an extensive amount of historical financial data.

In an attempt to overcome the shortfalls of the above mentioned approach for distinguishing strong and weak quality firms, Piotroski opted to follow a similar methodology to Lev and Thiaragarajan (1993). The approach used Lev and Thiaragarajan was to identify 12 statistically significant financial measures which could be used as signals to establish the financial strength of a specific firm and hence provide possible insight into its future share performance. These 12 financial measures selected were ones which were considered important to financial analysts when valuing a firm's financial health. These signals were only considered if they related to a firm's underlying fundamentals. The results of the study suggested that one was able to explain over 70% of the excess return of a share, using the financial measures selected for the study and after controlling for macroeconomic conditions. This study therefore provides an alternative approach to Frankel and Lee (1998) and Ou Penman (1989) and consequently is able to provide a methodology option which is not subject to complex data requirements and computation.

Piotroski leveraged off much of the above mentioned prior studies in an attempt to extend prior research through the use of context-specific financial performance measures to distinguish between the overall strength of firms given their fundamentals. In the Piotroski (2000) study, the methodology was altered as Piotroski opted to aggregate various binary financial signals instead of using a host of selected financial signals to determine a firm's financial strength. Using this framework combined with a focussed study on value firms with high book-market (BM) ratios, Piotroski presented a practical approach to using historical accounting-based information to predict future share performance for a firm.

2.2. Piotroski's F_Score as an indicator of future firm performance

The basic premise of the Piotroski (2000) study was to determine whether simple accounting-based information could be used along with a high BM firm portfolio to develop a strategy which generates abnormal excess returns. The result of this study was that Piotroski determined that there is a positive relationship between fundamental firm information and its future firm performance. The study's methodology is one that focusses on value firms, and as such aims not to analyse a firm's financial strength using absolute financial measures, but rather using the combination of absolute and changes in financial measures.

Piotroski selected nine accounting-based financial measures to evaluate three different elements of firm financial strength: profitability, leverage/liquidity, and operating efficiency. Each of the nine measures were given a binary score (1 – good, and 0 – bad) for the firm, which was then aggregated to arrive at an overall firm score out of nine. A score of 8 was considered an indication of improving firm strength and conversely a score of less than 2 would categorize firm as weak. As should be expected, the majority of the firm scores were between 3 and 7. This range was one which had reduced predictive ability for future returns as the financial measures had an increased likelihood of providing conflicting measures. The overall aggregate firm score (F_Score) was used with the mind-set that it would be able to provide insight into the future performance of the share relative to the market. Importantly, the measure is not focussed on determining firms with the best and absolute measures, but rather firms which have improved most significantly over recent history.

The author's findings were that high F_Score firms, on average, outperform low F_Score firms over a one year holding period by a mean return difference of 23% (High 13.4% and low -9.6%) which was found to be significant at the 1% level. He also found that there was a statistically significant (at 1% level) return differential between high F_Score firms and the mean market–adjusted return of the entire high BM quintile. He therefore established that from an overall viewpoint, the F_Score discriminates between eventual "winners and losers". He also determined

that when applying the F_Score to small, medium and large cap firm portfolios, he established that the strategy was only effective at differentiating between "winners and losers" in the small and mid-cap firms and was only marginally significant for large cap firms.

2.3. Piotroski F_Score in South African Context

Due to the success of this study and the robustness of its results, it proves to be an excellent starting point from which to extend further research into the South African context. Atwood (2012) replicated the Piotroski F_Score (Piotroski, 2000) study within the South Africa context in an attempt to examine whether the Piotroski F_Score investment strategy would provide statistically significant abnormal returns above the market. Similarly to the Piotroski, Atwood's premise was to determine "whether a fundamental, accounting-based analysis technique can discriminate between high book-to-market firms that will outperform their peers and those that will not." The findings of the Atwood study concluded that the F_Score strategy as presented by Piotroski (2000) was not statistically significant. Furthermore Atwood found that although the F_Score was able to successfully identify underperforming shares (low F_Scores) relative to the market, the strategy was unable to consistently identify financially strong companies which would outperform the market.

The Atwood study has presented conclusions which ultimately contrast several other studies (Mohanram, 2005; Mohr, 2012; Tantipanichkul, 2011; Galdi and Lopes, 2009) which have found the F_Score strategy to be statistically significant in numerous other developed and emerging equity markets alike. One possible reason for these unexpected findings is presumably as a result of the data limitations experienced in the Atwood study. Due to the data limitations under the South African context, Atwood was only able to collect the necessary data for the period 2005 to 2010. The author expressed further dissatisfaction with the study as a result of having to make a several assumptions in relation to retrieving the correct accounting-based company information. This resulted in Atwood having to relax a number of the Piotroski F_Score requirements in order to generate the 346 data points used in the study as compared to approximately 14,000 used in the original Piotroski study.

The study performed by Atwood (Atwood, 2012) provided important research into the effectiveness of the Piotroski F_Score (Piotroski, 2000) investment strategy in the South African equity market. Given the effectiveness F_Score's ability to generate statistically significant abnormal returns in previous studies around the world in both developed (Piotroski, 2000; Mohanram, 2005; Mohr, 2012) and emerging markets (Lopez and Galdi, 2007; Tantipanichkul, 2011, Hyde, 2013), it would be reasonable to have expected similar results for South Africa's FTSE/JSE.

The Atwood study aimed to replicate the original Piotroski (2000) for the period 2005 and 2010. The initial concern is the limited number of historical years used to test for the F_Score's effectiveness as a discriminatory measure between financially improving and deteriorating firms. The relatively short time period used by Atwood was unfortunately as a result of data constraints in the South African context.

Consistent to the Piotroski study, Atwood calculated the F_Scores for all firms listed on the FTSE/JSE over the selected period where firm financial data was reasonably available. Firms are then only selected for the high F_Score portfolio if it book-market value is within the first quintile of all high F_Score firms for the specified period. The high F_Score portfolios were then compared to a portfolio of low F_Score firms and the overall market using both subsequent 1 year and 2 year returns. Atwood then repeated the above methodology on the same sample however altering the cut-off selection criteria for the book-market value from top quintile firms only to any firm with a book-market value below 1. One final sample is then also used to establish whether or not the F_Score methodology can be used to generate long term outperformance without the use of the book-market value criteria.

The results of the Atwood study are undoubtedly concerning, however due to the circumstances of the findings, the Piotroski F_Score may still be statistically significant assuming that long period of time is used to test for the effectiveness of the strategy.

2.4. Mutual Funds Share Characteristics

There has been significant research which has gone into the illustrating the relationship between a fundamental firm information and the subsequent firm's future share performance. There is however substantially less research examining the relationship between the well documented relationship of firm fundamentals driving share returns and general equity manager returns. There have been a host of studies which substantiate studies like Piotroski's F_Score that firms with strong fundamentals outperform weak fundamental firms. Monhanram (2005) replicated the Piotroski study to confirm that when firms are evaluated on profitability, liquidity/leverage, and operation efficiency, firms with strong fundamentals (high F_Score) and high book-market ratios will outperform firms with weaker fundamentals (low F_Score). Similarly, Campbell, Hilscher, and Szilagyi (2008) found that firms with a lower bankruptcy probability outperformed firms tend to outperform shares which are approaching bankruptcy. As was indicated previously, the Piotroski F_Score framework focuses on assessing the relative improvement/deterioration of a firm and hence is able to distinguish between value traps on approaching bankruptcy and those firms which the market has

unfairly punished for a poor absolute balance sheet level. The results of the above mentioned studies also challenges the fundamental principles of the efficient market hypothesis (EMH) which suggests that more risky assets will generate a greater return than less risky assets on a relative basis (Fama and French, 1992; Fama 1998). In the Campbell, Hilscher, and Szilagyi (2008) study, the EMH was violated when evidence clearly indicated that the less risky and stronger fundamental firms in fact outperformed the more risky firms.

Therefore given the strong evidence supporting both the prevalence and practical applications of using historical firm fundamentals to predict future share performance, one would expect that there would be an erosion of these returns as sophisticated investors identify and eliminate the opportunity. The research question which consequently needs to be answered is whether professional sophisticated investors invest in shares based on the underlying firm's fundamentals. The research on this theme is very limited and is focussed around one study in particular, Zhou and Tice (2011) 'Mutual Funds and Stock Fundamentals'. In this study the authors look to establish whether professional money managers achieve abnormal returns using an investment strategy which relies upon the bottom-up analysis of historical fundamental firm information after controlling for management and transaction fees.

The methodology used by Zhou and Tice is one which uses the Piotroski F_Score as a proxy to test for the evidence of a fundamental trading strategy. Their motivation for using the Piotroski (2000) framework is due to the fact that the strategy has successfully illustrated that an investor is able to generate abnormal returns using a simple historical financial-based investment strategy. Zhou and Tice used a group of mutual equity funds managers as their proxy for sophisticated institutional investors present in the market. The study primarily focussed around whether the composition of the quarterly holdings of the various mutual equity funds were in any way correlated the market weighted F_Score of the funds. This relationship intuitively therefore centred around whether funds which had a higher F_Score would outperform funds with a lower F_Score on a relative basis.

The results of the Zhou and Tice paper revealed that as expected if a portfolio is constructed using a high BM shares along with a high F_Score, then will outperform on average a low BM portfolio with a low F_Score. Surprisingly when this was applied to mutual funds, it indicated that mutual fund do not slant their funds towards stocks with a higher F_Score. This was concluded as the US mutual funds used in the study did not have F_Scores' statistically different from the market as a whole on a market-weighted basis.

The results of this study provide the basis for further interesting studies into whether the similar trends would be apparent in the South African market and additionally whether the reason for the correlation between mutual fund excess returns and the F_Score strategy not being present is possibly due to structural limitations and/or institutional investor share preferences.

2.5. Institutional Investor Share Characteristics

Over the past decades, the research theme relating to the determination of the share characteristics sought after by institutional investors has been well documented. Prior empirical studies relating around this theme supports the premise that share characteristics are an important consideration for institutional investors when constructing a portfolio.

The wider spectrum of factors affecting the stock selection process for institutional investors is supported by prior work from Falkenstein (1996), Gompers and Metrick (2001), Pinnuck (2004), Brands, Gallagher, and Looi (2006).

In the Pinnuck study, it was identified that a portfolio manager is generally required to address three important investment considerations when evaluating a stock for inclusion into a portfolio. As highlighted in the study, Pinnuck identifies these considerations as: the type of stocks which the manager should been exposed to in order to achieve the fund's investment objectives; the maintenance of prudent stock selection process; and the suitability of a stock given the portfolio manager's unique information resources.

Following on from the findings of Pinnuck, a study presented by Brands, Gallagher, and Looi (2006) further developed the notion of institutional investors' preference for shares with certain characteristics. The study determined aggregate results for the Australian equity market which indicated that active mutual fund managers display a common preference for stock with "higher stock price variance, lower transaction costs, larger market capitalisation, preferences toward value stocks, securities with higher analyst coverage, and stocks with a lower standard deviation in analyst earnings forecasts."

2.6. Motivation for Research

The motivation for extending prior research in this field of study is primarily to better understand whether the robust results that have been concluded for developed markets are in fact consistent with those of emerging and/or developing markets. Emerging markets, such as South Africa, are often victim to significant data constraints and unique market characteristics which often lead to inconsistent results as compared to more developed and efficient capital markets. There has

been prior work focussing on the Piotroski F_Score within the emerging market context (Atwood, 2012; Lopez and Galdi, 2007; Tantipanichkul, 2011, Hyde, 2013) with mixed results. The results concluded by Lopes and Galdi, Tantipanichkul, and Hyde all confirmed that there was in fact statistically significant evidence to conclude that the Piotroski F_Score strategy also effective in emerging markets. Furthermore, Hyde (2013) recently concluded that the Piotroski F_Score was statistically significant in Korea, India, China, Brazil and South Africa. This conclusions delivered by the Hyde (2013) provide a strong basis for further investigation given the fact Atwood (2012) found the F_Score methodology not to be statistically significant over the period 2005 to 2010. This provides the necessary backdrop to establish which of these prior studies' findings should be considered refutable.

The relationship between the Piotroski F_Score and equity manager holdings is one area which has not seen substantial prior research. Zhou and Tice (2011) concluded that US equity managers do not in any way tilt their funds towards high F_Score firms in an attempt to generate excess market returns. These results provide an interesting precedent on initial work, which ultimately addresses the question of why does the F_Score investment strategy generate excess returns if there are sophisticated equity managers able to exploit this opportunity.

3. METHODOLOGY

3.1. Original Piotroski F_Score (2000)

The methodology used in this study is primarily in replication of the Piotroski (2000) study whereby the nine measures are used in order to calculate a share's F_Score. Piotroski developed the F_Score framework on the back of prior work by Lev and Thiagarajan (1993) whereby the authors identify 12 financial signals considered important to analysts when preparing fundamental share analysis. Lev and Thiagarajan found that there was a direct correlation between a share's 12 financial measures and the subsequent returns even after adjusting for earnings innovations, firm size, and macroeconomic conditions. These findings were then further confirmed by Abarbanell and Bushee (1997, 1998) as they evaluated the accuracy of the Lev and Thiagarajan study. Aberbanell and Bushee concluded that an investment strategy based upon the 12 financial signals does generate statistically significant abnormal returns.

Piotroski's nine financial signals were as such prepared with the intention of achieving similar results to the Lev and Thiagarajan study, whilst still ensuring that the financial signals remained straightforward to calculate and that the fundamental information required was publicly available. The resultant nine financial signals focussed on a shares profitability, leverage and liquidity, and operational efficiency. The following methodology relating to the F_Score components has been replicated from the Piotroski (2000) study with noted minor amendments.

3.1.1. **Profitability**

The profitability component of the F_Score addresses the premise that current profitability and cash flow realisations provide insight into the firm's ability to generate funds through their primary business activities. Due to the bias towards value firms as a result of Piotroski (2000) only focussing on shares with high BM ratios, the profitability component of the F_Score is particularly important as value firms tend to have poor absolute levels of profitability and cash flow measures compared to growth firms on a relative basis. The implications however for a value firm with improving profitability and cash flow measures are great as it indicates significant increased ability to generate internal funds through operating activities. There are four measures which are used to evaluate a firm's profitability under the F_Score framework.

3.1.1.1. Positive Return on Assets (F_ROA)

This signal is calculated as firm's net income before any extraordinary items divided by the average total firm assets. Average total assets is defined as the average of the total asset value for the current and previous financial years. If the firm's current ROA is positive, the measure is awarded a score of 1, else zero.

3.1.1.2. Positive Cash Flow from Operations (F_CFO)

The cash flow from operations value (CFO) is used directly off the firm's current annual financial statements. . If the firm's current CFO is positive, then the measure is awarded a score of 1, else zero.

3.1.1.3. Change in Return on Assets (F_ΔROA)

Firms with an increasing year-on-year return on assets (i.e. ROA (t) > ROA (t-1)) are awarded 1, else zero. This measure identifies increased operational efficiency either through increased profits using stable asset base or alternatively stable profits with a lower asset base.

3.1.2.**Quality of Earnings: Accrual Measure (F_ACCRUAL)**

The relationship between profits and cash flows is also considered. Sloan (1996) showed that a positive earnings accrual (i.e. profits greater than cash flow from operations) is an unfavourable signal for a firm's future ability to generate profits and positive returns. Therefore this measure is valued at one when net income before extraordinary items is less than cash flow from operations.

3.1.3.**Leverage, Liquidity, and Source of Funds**

These measures are grouped to identify the firm's ability to meet future debt obligations and its changes in capital. The assumption underlying this measure is that for value firms, a deterioration of liquidity, an increase in leverage or increase external funding are all considered bad signals and would increase the financial risk of the firm in the future. Even though this measure focusses on value firms, as characterised by BM value, this assumption made for this study is considered to hold for all firms irrespective of BM value.

3.1.3.1. Change in Leverage (F_ΔLEVER)

Piotroski measures change in leverage as the changes in debt levels, and specifically, total long-term debt to average total assets. A year-on-year increase in this ratio is considered a negative firm signal. This can be viewed as a somewhat ambiguous signal given the fact that raising external capital is considered a negative signal without any consideration for the debt level. The importance of measure is as a result evidence supported by studies such as Myers and Majluf (1984) and Miller and Rock (1985), which supports the fact that raising external financing often indicates a firm's inability to generate the funds internally. This is consistent with the Piotroski approach, in aggregate, as the focus of the F_Score is not intended to evaluate the absolute level of firm financial strength, but rather the change in financial strength.

3.1.3.2. Change in Liquidity (F_ΔLIQUID)

Measures the change year-on-year of the firm's current ratio. The current ratio is defined as the firms total current assets divided by total current liabilities. An increasing current ratio is considered a positive signal and is therefore assigned a score of 1, with a decreasing ratio assigned 0. The current ratio inclusion attempts to account for a firm's improved liquidity.

3.1.3.3. Change in Shares Outstanding (EQ_OFFER)

If the firm has increased the amount of common shares in issue in the current year, then the firm is considered to have deteriorated its ability to generate future returns. The assumption is that the firm is signalling to the market that it is not able to generate sufficient internal funds to service future opportunities. Share buy-backs are considered positive signals and would hence provide a firm with a score of one.

3.1.4. **Operating Efficiency**

The final two ratios are used to analyse the operational efficiency of the firm comparing year on year changes in the gross margin and turnover.

3.1.4.1. Change in Gross Margin (F_ΔMARGIN)

The assumption for the gross margin measure is that an increase in the gross margin indicates that the firm would have improved its ability to generate positive returns in the future. An increasing year-on-year gross margin is assigned a score of 1, else zero. Due to the fact that many South African firms do not explicitly report gross revenue and as such the operating efficiency measure has been proxied by the firm's operating margin wherever the gross margin was unavailable.

3.1.4.2. Change in Asset Turnover (F_ΔTURN)

An increase in the firm's asset turnover from one year to the next indicates that the firm's assets are operating more efficiently than previously. This increased productivity could be the result of either a smaller asset base or increased sales. Whichever is the case, it will result in a value of one and a positive signal.

3.1.5. **Composite Score**

The study variables used by Piotroski are also similar to those used by Lev and Thiagaranjan (1993) and Abarbanell and Bushee (1997, 1998). However most of the actual measures used in the Piotroski study are not used in the previous studies above mentioned.

In summary, the F_Score can be mathematically represented as the following equation:

F_Score = F_ROA + F_CFO + F_ΔROA + F_ACCRUAL + F_ΔMARGIN + F_ΔTURN + F_ΔLEVER + F_ΔLIQUID + EQ_OFFER

As highlighted previously, the various nine measures are then aggregated to achieve and overall aggregate F_Score. Intuitively, a firm with a high F_Score will have mostly good signals as indicated by a higher score. The essence of the Piotroski study is to prove that his premise that the level of the F_Score will be directly related to changes in the firms' future performance and returns. The Piotroski methodology is different to previous studies by Ou and Penman (1989) and Holthausen and Larker (1992) as it highlights investment opportunities using a number of different measures instead of relying on one or two fundamental measures. It must however be noted that there is one clear concern with the Piotroski F_Score approach, which relates to the risk of losing potentially important firm financial data as this information is converted into binary format and aggregated.

There are a number of fundamental differences between this study and the study that was performed by Atwood (2012). The first is that F_Scores have been calculated on a quarterly calendar basis instead of the annual basis as presented in Atwood (20012) and Piotroski (2000). The reason for this change is as a result of the limited number of historical years available for the FTSE/JSE though publicly available resources. The use of quarterly rebalancing effectively increases the number of data points in the hope that it will improve the statistical significance of the F_Score methodology in the South African context. The holding period is therefore a rolling 3 month period which is in contrast to that of the two above mentioned studies which look to analyse the subsequent portfolio returns over both a 1 year and 2 year period. The result of this change to quarterly rebalancing and therefore quarterly subsequent returns is that it is able to increase the research period as the subsequent return's holding period requirement decreases. This methodology is consistent a study by Zhou and Tice (2011) which similarly calculated quarterly firm F_Scores and then geometrically linked the returns over the selected period. Importantly this approach allows for more timely addition of shares to a high F_Score portfolio on a quarterly basis rather than the more passive approach of annual rebalancing as presented by Piotroski (2000). Additionally the quarterly approach to rebalancing also allows for more timely removal of firms with deteriorating fundamentals and thereby an F_Score which is no longer considered to be a high F_Score.

The share universe which has been used in this study is one which accounts for 99% of the FTSE/JSE market capitalisation. Due to the large number of illiquid stock present on the FTSE/JSE

Securities Exchange, on average, only the top 168[1] shares with the necessary firm information have been used in the study. The reason for this limitation is due to the nature of the South African equity market whereby the largest 40 shares as per market capitalisation have accounted for an average of 85% of the entire FTSE/JSE market capitalisation[2]. It is as a result of this characteristic that many of the smaller illiquid shares have not been considered in the study due to the fact that only the firms with a market capitalisation, as ranked by size, within the cumulative 99% level have been considered. This change in methodology provides the study with the ability for replication by individual and institutional investors without having to be significantly affecting by liquidity constraints and bid-ask spread implicit costs.

The next fundamental difference to the methodology of this study relates to the use of the book-market measure (BM). In the original study by Piotroski, and as replicated with slight modifications by Atwood, the F_Score was calculated annually for all firms in the market. The selection criteria to then create a high F_Score portfolio was to identify firms with a high F_Score (8 or 9 in the Piotroski methodology) and only select firms with a high BM value. The book-market level was then calculated as the top quintile of all high F_Score firms for that period.

Using the South African equity universe of the largest shares on a ranked basis to the 99% cumulative level, the F_Score framework only returns an average of 7 shares each quarter which actually meet the criteria of having an F_Score of 8 or 9. Even when all firms with an F_Score of 7 are included, the average number of shares in the high F_Score universe only increases to 23. As a result of this finding, there have been further changes to the original F_Score methodology. The first is that the high F_Score definition has been expanded to include all firms with an F_Score equal to or greater than 7. The purpose of this modification is to ensure that the high F_Score portfolio is not overly concentrated in only a handful of share and in some instances on a single share. The second modification relates to the use of the BM value as a filtering criterion. This study does not use the BM ratio to create the high F_Score portfolio. The reason for this is due to the limited number of shares which are consistently returned as having high F_Scores. By not filtering on the BM, and as such not only selecting the quintile with the highest BM ratios, the portfolios created in this study are able to participate in the benefits of holding a diversified portfolio. Diversification is an exceptionally important consideration for both individual and institutional investors and as such this study is intended to remain consistent with this characteristic as to allow the straightforward

[1] The average number of shares that made up the cumulative 99% of the FTSE/JSE was 168. This average number of shares was determined over the entire period of the study, and shares that dropped out of this 99% range were still included going forward.

[2] As at 31 December 2012, the largest 40 shares on the FTSE/JSE accounted for approximately 85% of the total market. There have been no free-float adjustments made in this calculation. Data sourced from Bloomberg LP on 5 August 2013.

replication of the is study through the use of publicly available data. The high F_Score portfolio therefore has a range of 8 to 37, with an average of 23 shares over the period.

Atwood (2012) alluded to the fact that the results of the study clearly indicated that there was a positive relationship between the firm F_Score value in aggregate and the subsequent 12 month and 24 month returns. More importantly however, although it was clearly illustrated that high book-market firms with a high F_Score outperform low F_Score firms over both time periods, unfortunately these results were not statistically significant. One reason for such a conclusion was as a result of the high return variability and the inherent short time period selected to perform the study.

In order to ensure that the following study would be able to be replicated by both individual and institutional investors alike, the firm financial information which is used to calculate the composite F_Score must have been publicly available for at least 3 months before it can be considered into the calculation. This is shorter than the 5 month period used by Atwood (2012), however it is consistent with Zhou and Tice (2011) where a 3 month lag period was used to calculate quarterly firm F_Scores of US equities over the period 1976 to 2008. The 3 month lagged firm financial data was then used by Zhou and Tice to subsequently rebalance the high F_Score portfolios on a calendar quarter basis.

As highlighted by Zhou and Tice, even though Piotroski delivered compelling evidence for the effectiveness of the F_Score strategy when comparing high BM firms, Piotroski never provided empirical findings examining whether the F_Score relationship holds for low BM firm alike. Subsequently, Zhou and Tice (2011) concluded that the "the F_Score strategy is profitable both for firms in the highest BM quintile and the firms in the lowest BM quintile". Furthermore the study found that over the period of 1979 to 2006, "the average one-year buy-and-hold return for a hedged portfolio which takes a long position in high F_Score (>=7) firms and a short position in low F_Score (<=3) firms is 11.8% for high BM firms, and 19.8% for low BM firms." Additionally the authors deliver findings that conclude the profitability strategy for the low book-market firms is higher than the high BM firms at the 1% level. This provides the groundwork for evidence which questions whether the Piotroski F_Score is only applicable to a strategy which focusses only on value firms with high BM ratios. Similarly to the prior research by Zhou and Tice, this study does not exclude any firms according to their respective BM ratio.

The original Piotroski F_Score investment strategy for high book-market firms uses firms with an F_Score of 8 and 9 in the construction of the high F_Score portfolios. Conversely, the original study also only considers firms with an F_Score of 0 or 1 in the construction of the low F_Score

portfolios. Zhou and Tice (2011) altered the F_Score portfolio construction methodology by including firms with an F_Score of greater than 6 for high F_Score portfolios and less than 4 for the low F_Score portfolios. The comprehensive findings of the Zhou and Tice study suggest that it would be reasonable to expand the high and low F_Score portfolio criteria in an attempt to offset the various limitations experienced under the South African context. Given the fact that the South African equity market is largely dominated by large market capitalisation firms, the investable universe is significantly limited for institutional investors due to liquidity constraints and ownership constraints. In an attempt to maintain a balance a between following the original Piotroski methodology and ensuring that there is a large enough sample size for both high and low F_Score portfolios, the portfolio criteria for a high and low F_Score are greater than 6 and less than 3 respectively.

As a result of missing firm financial data, any instance whereby more than 2 F_Score components have missing data, the F_Score will not be calculated for the specific quarter and hence its return will not be considered in the subsequent performance calculations. In the original Piotroski, any firm which did not have available data for all 9 F_Score components would be excluded from the study. This criterion is however biased against many financial firms in the South African context as a result of the industry standard not reporting a gross profit line item in the financial statements. Due to the small universe present under the South African context, a similar methodology has been used to that of Atwood (2012) whereby firms have still been included in the study assuming there are no more than 2 F_Score components missing. Furthermore, in an attempt to ensure that financially strong firms are correctly grouped by their F_Score, any firm which has a score of 5 or more and is missing at least 2 F_Score data inputs will be adjusted upwards by two points (For instance a firm has an F_Score of 5 and is missing 3 data inputs will be awarded an effective F_Score of 7and will be included in the study.

3.2. Data Sample

3.2.1. Individual Stock Sample

The sample period used to evaluate the effectiveness of the F_Score methodology presented in this study is from January 2004 through December 2012. The data period has been extended from the 6 year period used in Atwood (2012) in the intent to statistically test the effectiveness of the strategy over a longer time period. The study therefore starts by establishing whether the Piotroski F_Score, at the most basic level, is prevalent on the FTSE/JSE over the time period selected. In replication of the methodology as presented by Zhou and Tice (2011), the firm F_Scores are calculated on a quarterly basis and are then compared to their respective 3-month subsequent share returns. In an effort to also compare the results of this study to that of Atwood (2012), the quarterly firm F_Scores have also be included for an investment strategy using a 12-

month holding period and therefore annual rebalancing. The period for analysis was however required to be shortened due to the fact that the F_Score requires year on year data in places and that the F_Score needs a 1 year holding period in order to observe results. All firm financial data used in the calculation of the F_Scores was retrieved using Bloomberg LP.

Even though the firm financial information was collected on a quarterly basis, using a 3 month lag period in order to ensure that the detail had sufficient time to disseminate to the market, the information used was annually reported data and hence if there was no updated data for a current quarter, the previous quarter's information would be used. All firm share price returns were calculated after having adjusted for all corporate actions, dividends, scrip dividends, and rights issues. All returns used in this study are therefore calculated on a total return basis but before transaction costs.

Given the detailed information required from equity managers, the ten year time period presents the study with a sufficiently long period of analysis whilst still allowing for the information to be collected through standard data sources and maintaining data integrity. This effectively leaves the study with 5,873 firm- quarters.

3.2.2.Unit Trust Sample

In order to evaluate whether there is any relationship present between the returns generated by the Piotroski F_Score strategy and the returns captured by sophisticated equity managers in South Africa, I have opted to analyse the quarterly holdings of the domestic equity class of unit trusts. Unfortunately due to publicly available data constraints, the period selected for analysis is only a 3-year period from December 2009 to December 2012. The equity funds selected were a function of whether the fund was included in the ASISA General Equity category and whether there was accessible quarterly holdings data which could be used in the calculation of the fund market-weighted aggregate F_Score (Fund_Score). Funds were not eliminated from the study due to fund characteristics such as investment style or fund size, however similarly to the Zhou and Tice, index funds and fund of funds were eliminated from the sample as those funds' characteristics are not applicable to the requirements of the study.

3.3. Empirical Design

3.3.1. Test for evidence of the Piotroski F_Score

The first test required by this study related to establishing whether the Piotroski F_Score methodology is effective within the South African equity market. Prior work by Atwood (2012) concluded that whilst the high F_Score portfolio's outperformed low F_Score portfolios over the 1 and 2 year holding periods, the results were unfortunately not statistically significant. The study

performed by Atwood was primarily a full replication study of Piotroski (2000) over the period 2005 to 2010. After having taken the previous Piotroski F_Score study on the South Africa equity market into account, this study will look to investigate whether the F_Score methodology can be used as an investment strategy in the domestic market. The most significant changes to this study's approach to testing for the effectiveness of the F_Score investment strategy is the use of a quarterly rebalancing approach and a longer time period (January 2004 to December 2012).

This study will first test for whether the returns generated by the high F_Score portfolio are statistically significantly different from those generated by the low F_Score on a quarterly basis. This will be done using two sample t-tests assuming unequal variances. High F_Score portfolio's will be rebalanced quarterly to an equal weighting of all firms with an F_Score of 7 or greater whereas the low F_Score portfolios will be constructed similarly only using firms with an F_Score of 2 or less. Similarly, the high F_Score portfolio will also be tested using t-tests to establish whether it is able to generate abnormal returns above that of the overall market (equally-weighted). From a portfolio construction perspective, due to the limited number of securities used within this study, a two have been amalgamated into other larger F_Score categories. Specifically, the firms with an F_Score of 0 have been incorporated into the F_Score category 1 firms and the similarly firms with an F_Score of 9 have been included into the F_Score category 8 firms.

In an attempt to also address past research findings, this study will also repeat the above mentioned process using a 12-month subsequent holding period as opposed to the 3-month holding period initially used. Due to the limited number of data points available for this study, the 12-month holding period investment strategy with annual rebalancing has be tested for statistical significance using an 8-year investment period from 2004 to 2012 with 4 different quarterly start dates. The reason for this choice of approach is simply in an attempt to increase the number of data points which can be used to test for the effectiveness of the F_Score strategy. This approach however is at admittedly susceptible to the risk of autocorrelation which is effectively the potential risk that the results which are concluded could be misleading due to the lag variables present in the data. The results have not been tested for autocorrelation due to the limited of scope of this study.

Given the fact that the Piotroski F_Score methodology has proven to be statistically significant in a number of previous studies (Piotroski, 2000 and 2002; Mohanram, 2005; Mohr, 2012) and emerging markets (Lopez and Galdi, 2007; Tantipanichkul, 2011; Hyde, 2013), at both differentiating between firm quality and as a predictor of future firm performance, this study further aims to establish whether fund managers tilt their portfolios towards high F_Score firms. The rationale for researching this theme is due to the presence of an investment strategy that delivers abnormal returns above the market which is easily replicable and as such one would expect

sophisticated institutional investors to exploit this opportunity until abnormal returns are no longer possible.

The period over which the fund manager data has been collected is from December 2009 to September 2012. The reason for the short time period is unfortunately due to the lack of publicly available access to the quarterly underlying holdings of domestic equity managers within South African borders. The data was collected from ASISA for the above mentioned period, whereby each firm in the sample selection had its fund F_Score (Fund_Score) calculated given the underlying firms' F_Scores and the respective quarterly weightings in the fund.

The equity fund universe was then tested to establish whether or not there was any relationship between the Fund_Scores and the subsequent return of the managers. This was test on an absolute level and a relative level where the Fund_Scores were ranked into quartiles from largest to smallest and the effective subsequent returns were calculated for the various fund quartiles. The aim of the relative testing for a relationship is to establish whether or not there is an underlying theme present which concerns whether it is possible to differentiate between equity fund performances based on current ranked Fund_Scores relative to the fund universe.

4. RESULTS

4.1. Test for effectiveness of the Piotroski F_Score

As was highlighted in the empirical design of this study, the initial test used to establish the effectiveness of the Piotroski F_Score strategy was a t-test assuming unequal variances. The results of the initial test are summarised in Table 1. Table 1 provides descriptive statistics used in testing the effectiveness of the Piotroski F_Score in differentiating between financially strong and weak firms and its subsequent ability to generate superior returns by holding a long-only portfolio of firms with high F_Scores. The results summarised in Panel B indicate a clear positive relationship between a firm's quarterly F_Score and its subsequent 3 month market-adjusted return. At the extreme range, there is a 4.59% difference in average quarterly market-adjusted returns between firms with an F_Score of 8 to 9 (+3.38%) and firms with an F_Score of 0 to 1 (-1.21%). Similarly when the F_Score methodology is implemented as an investment strategy with quarterly rebalancing, the average return differential between the high F_Score (2.82%) and the low F_Score (-1.81%) portfolios is 4.64% and is statistically significant at the 5% percent level. Moreover the average quarterly market-adjusted returns generated by the high F_Score portfolio are also statically significant from the overall market at the 5% level. Interestingly, Panel A indicates that the differences in quarterly returns is so prevalent for the selected period that the high F_Score portfolio returns are even statistically significantly different (5% level) from the low F_Score portfolios on a raw returns basis.

The results of the Piotroski F_Score adapted methodology clearly illustrates that the F_Score is effective in differentiating between financially strong and weak firms within the South African equity market context. Similar methodology was used to establish whether the results concluded by Atwood (2012) would be consistent given the fact this study does not discriminate firms based on their respective book-market ratios in the portfolio construction process. The above process was therefore repeated for an investment strategy that incorporated a 12-month holding period with annual rebalancing. The results of this study are summarised in Panel C which indicated the one-year market adjusted returns of the various F_Score categories. Similarly to the results of the 3-month study, the high F_Score investment strategy is statistically significant, at the 5% level, against both the equally-weighted market (F_Score 0-9) and the low F_Score portfolios. The average 12-month market-adjusted return differential between the high F_Score portfolio and the market and low F_Score portfolio was 4.4% and 7.9% respectively.

These findings are consistent with the findings by Atwood (2012), which concluded that the high F_Score portfolio generated market –adjusted returns in excess of both the market and the low

F_Score portfolios. The results of this study however is also able to prove that the return differential generated by the F_Score methodology employed by this study, is statistically significant before the effect of any explicit and implicit trading costs.

Table 1: Buy-and-Hold Portfolio Returns for an F_Score Investment Strategy

The below table summarises the results of a quarterly rebalanced investment strategy which is centred on the F_Score methodology without the use of the book to market ratio as a screening criterion. The F_Score is an aggregate score of nine underlying binary financial signals used to evaluate the change in firm financial strength, or

$$F\_Score = F\_ROA + F\_CFO + F\_\Delta ROA + F\_ACCRUAL + F\_\Delta MARGIN + F\_\Delta TURN + F\_\Delta LEVER + F\_\Delta LIQUID + EQ\_OFFER$$

The financial signals are binary measures which are allocated a score of 1 when the respective criteria is met as it is associated with a firm with improving financial fundamentals. Firms with a score of less than 3 are assigned to the Low F_Score portfolio whereas firms with a score of greater than 6 are grouped in the High F_Score portfolio. The 0-9 portfolio is a market portfolio of equally weighted firms.

The observations for each F_Score category were ranked in descending order according to subsequent return. The percentage columns in Panels A, B, and C relate to the average return for the respective percentage proportion of all ranked observations (Example, 90% is the average subsequent return of all returns excluding the highest 10% of ranked returns).

Panel A: 3-Month Raw Returns

F_Score	Mean	10%	25%	50%	75%	90%	% Positive[a]	*n*
0 - 1[b]	0.0492	-0.1283	-0.0791	-0.0412	-0.0158	0.0109	0.5294	138
2	0.0540	-0.1591	-0.0832	-0.0391	0.0014	0.0251	0.6389	403
3	0.0613	-0.1176	-0.0672	-0.0269	0.0066	0.0319	0.7059	919
4	0.0701	-0.1346	-0.0723	-0.0175	0.0241	0.0494	0.7353	1357
5	0.0776	-0.1377	-0.0761	-0.0173	0.0293	0.0565	0.7353	1249
6	0.0741	-0.1318	-0.0669	-0.0147	0.0265	0.0514	0.7353	991
7	0.1009	-0.1193	-0.0510	0.0095	0.0552	0.0804	0.7647	583
8 - 9[b]	0.1027	-0.1142	-0.0304	0.0169	0.0554	0.0800	0.8529	233
3 - 6	0.0708	-0.1217	-0.0692	-0.0175	0.0242	0.0514	0.7647	4516
0 - 9[c]	0.0730	-0.1142	-0.0650	-0.0150	0.0270	0.0541	0.7647	5873
High F_Score	0.0986	-0.1075	-0.0398	0.0137	0.0546	0.0784	0.7941	816
Low F_Score	0.0532	-0.1414	-0.0773	-0.0370	0.0038	0.0280	0.6176	541
High less Low[d]	0.0455	0.0339	0.0375	0.0507	0.0507	0.0504		
High Less All[e]	0.0257	0.0067	0.0252	0.0286	0.0275	0.0243		

t-Test: Two-Sample Assuming Unequal Variances - 5% Significance Level

	P(T<=t) one-tail	t Stat	t Critical one-tail
High less Low	0.0459	1.7101	1.6676
High Less All	0.1637	0.9864	1.6676

[a] The % Positive column indicates how many observations as a percentage of total observations were positive for the selected period.

[b] Firms with an F_Score of 0 or 9 have been grouped with firms with an F_Score of 1 and 8 respectively. The reason for not displaying the results of firms with an F_Score of 0 or 9 separately is primarily due to the fact of limited observations for both F_Score categories.

[c] The '0 – 9' F_Score portfolio represents the market portfolio of all securities in the universe equally weighted.

[d] The 'High less Low' value relates to the return differential generated by the high F_Score portfolio less the low F_Score portfolios

[e] The 'High less All' value relates to the return differential generated by the high F_Score portfolio less the 0 -9 F_Score portfolio.

Panel B: 3-Month Market-Adjusted Returns

F_Score	Mean	10%	25%	50%	75%	90%	% Positive	*n*
0 - 1	-0.0121	-0.1914	-0.1345	-0.0967	-0.0690	-0.0468	0.3529	138
2	-0.0151	-0.0998	-0.0747	-0.0588	-0.0467	-0.0361	0.1944	403
3	-0.0096	-0.0693	-0.0563	-0.0451	-0.0339	-0.0262	0.2778	919
4	-0.0006	-0.0612	-0.0383	-0.0233	-0.0142	-0.0085	0.4167	1357
5	0.0060	-0.0391	-0.0253	-0.0156	-0.0072	-0.0019	0.5278	1249
6	0.0036	-0.0577	-0.0357	-0.0204	-0.0103	-0.0052	0.5278	991
7	0.0310	-0.0643	-0.0310	-0.0073	0.0086	0.0168	0.7500	583
8 - 9	0.0338	-0.1037	-0.0697	-0.0328	-0.0082	0.0045	0.6389	233
3 - 6	-0.0015	-0.0201	-0.0135	-0.0092	-0.0060	-0.0042	0.3889	4516
0 - 9	-	-	-	-	-	-		5873
High F_Score	0.0282	-0.0545	-0.0309	-0.0076	0.0078	0.0166	0.7500	816
Low F_Score	-0.0181	-0.0748	-0.0685	-0.0564	-0.0425	-0.0326	0.2222	541
High less Low	0.0464	0.0204	0.0376	0.0487	0.0503	0.0492		
High Less All	0.0282	-0.0545	-0.0309	-0.0076	0.0078	0.0166		

t-Test: Two-Sample Assuming Unequal Variances - 5% Significance Level

	P(T<=t) one-tail	t Stat	t Critical one-tail
High less Low	0.0001	3.4139	1.6909
High less All	0.0008	3.4139	2.4411

Panel C: One-Year Market-Adjusted Returns

F_Score	Mean	10%	25%	50%	75%	90%	% Positive	*n*
0 - 1	-0.018	-0.453	-0.318	-0.196	-0.123	-0.077	0.406	132
2	-0.041	-0.245	-0.216	-0.157	-0.115	-0.084	0.281	369
3	-0.042	-0.220	-0.178	-0.144	-0.113	-0.092	0.250	832
4	0.006	-0.123	-0.090	-0.057	-0.035	-0.020	0.438	1234
5	0.006	-0.076	-0.062	-0.041	-0.020	-0.005	0.469	1132
6	0.004	-0.150	-0.102	-0.060	-0.033	-0.018	0.500	892
7	0.040	-0.229	-0.140	-0.079	-0.025	0.009	0.594	546
8 - 9	0.084	-0.325	-0.174	-0.075	-0.009	0.028	0.719	216
3 - 6	-0.004	-0.047	-0.037	-0.025	-0.017	-0.013	0.344	4090
0 - 9	-	-	-	-	-	-	-	5353
High F_Score	0.044	-0.242	-0.128	-0.051	-0.008	0.020	0.750	762
Low F_Score	-0.035	-0.232	-0.208	-0.148	-0.103	-0.074	0.313	501
High less Low	0.079	-0.010	0.079	0.098	0.095	0.094		
High Less All	0.044	-0.242	-0.128	-0.051	-0.008	0.020		

t-Test: Two-Sample Assuming Unequal Variances - 5% Significance Level

	P(T<=t) one-	t Stat	t Critical one-tail
High less Low	0.0115	2.3321	1.6698
High less All	0.0261	1.9793	1.6698

Table 2: Spearman Correlation Analysis

The nine components of the F_Score included in the Spearman Correlation analysis have all been standardised on a Z-Score basis. The 3-month returns represented below are calculated on calendar quarter basis after having incorporating a 3-month lag period as to allow for all firm financial information to be effectively disseminated into the market. The market-adjusted return reported in Panel B is simply the High F_Score portfolio return less the equally-weighted market portfolio (F_Score 0 – 9) return. The sample size for Panel A and Panel B was 5,873 with 816 firm-quarter observations.

Panel A: Spearman Correlation Analysis for the 3-month return, the correlations of the fundamental signals and the F_Score for all securities in the selected share universe

	3M RETURN	F_ROA	F_CFO	F_ΔROA	F_ACCRUAL	F_ΔLEVER	F_ΔLIQUID	EQ_OFFER	F_ΔMARGIN	F_ΔTURN	F_SCORE
3M RETURN[a]	1.0000	-0.0186	0.0097	0.0528	0.0019	-0.0080	0.0015	-0.0124	0.0077	0.0307	0.0753
F_ROA[c]	-	1.0000	0.0677	0.2667	-0.2739	-0.0926	0.0382	-0.0584	0.0964	0.0896	0.2417
F_CFO[d]	-	-	1.0000	0.0455	0.6912	-0.0499	0.0251	0.0053	0.0098	-0.0079	0.3122
F_ΔROA[e]	-	-	-	1.0000	-0.1542	-0.0964	0.0466	-0.0343	0.1666	0.2363	0.2907
F_ACCRUAL[f]	-	-	-	-	1.0000	0.0176	-0.0224	0.0118	-0.0281	-0.0138	0.1882
F_ΔLEVER[g]	-	-	-	-	-	1.0000	0.1266	0.0044	-0.0238	-0.0448	-0.2366
F_ΔLIQUID[h]	-	-	-	-	-	-	1.0000	0.0281	0.0383	0.0131	0.2074
EQ_OFFER[i]	-	-	-	-	-	-	-	1.0000	0.0045	-0.0701	-0.1201
F_ΔMARGIN[j]	-	-	-	-	-	-	-	-	1.0000	0.0762	0.2793
F_ΔTURN[k]	-	-	-	-	-	-	-	-	-	1.0000	0.3193
F_SCORE[l]	-	-	-	-	-	-	-	-	-	-	1.0000

[a] 3M RETURN 3-month Subsequent Return
[b] 3M MA RETURN 3-month Subsequent Market-Adjusted Return
[c] F_ROA Positive Return on Assets
[d] F_CFO Positive Cash Flow from Operations
[e] F_ΔROA Change in Return on Assets
[f] F_ACCRUAL Quality of Earnings: Accrual Measure

[g] F_ΔLEVER Change in Leverage
[h] F_ΔLIQUID Change in Liquidity
[i] EQ_OFFER Change in Shares Outstanding
[j] F_ΔMARGIN Change in Gross Margin
[k] F_ΔTURN Change in Asset Turnover
[l] F_SCORE = F_ROA + F_CFO + F_ΔROA + F_ACCRUAL + F_ΔMARGIN + F_ΔTURN + F_ΔLEVER + F_ΔLIQUID + EQ_OFFER

Panel B: Spearman Correlation Analysis for the 3-month return, the correlations of the fundamental signals and the F_Score for the high F_Score portfolio

	3M RETURN	3M MA RETURN	F_ROA	F_CFO	F_ΔROA	F_ACCRUAL	F_ΔLEVER	F_ΔLIQUID	EQ_OFFER	F_ΔMARGIN	F_ΔTURN	F_SCORE
3M RETURN[a]	1.0000	0.1791	-0.0676	-0.1946	0.3875	0.0402	-0.0134	-0.2572	-0.4170	0.1806	0.3019	0.2405
3M MA RETURN[b]	-	1.0000	0.0483	0.2101	0.1036	0.1610	0.0866	0.0791	-0.1261	-0.1607	-0.2771	0.3075
F_ROA[c]	-	-	1.0000	0.2139	-0.0057	0.0395	-0.3468	0.0519	-0.0597	-0.1031	-0.0450	-0.3735
F_CFO[d]	-	-	-	1.0000	-0.4557	0.7656	-0.0023	0.1326	0.2833	-0.6303	-0.4926	0.2123
F_ΔROA[e]	-	-	-	-	1.0000	-0.3235	-0.3855	-0.1945	-0.3395	0.4589	0.5089	0.1324
F_ACCRUAL[f]	-	-	-	-	-	1.0000	0.1980	0.0180	0.1094	-0.5709	-0.1782	0.3276
F_ΔLEVER[g]	-	-	-	-	-	-	1.0000	0.0934	-0.1428	-0.2143	0.1993	0.2349
F_ΔLIQUID[h]	-	-	-	-	-	-	-	1.0000	-0.1287	-0.4780	-0.2292	0.0484
EQ_OFFER[i]	-	-	-	-	-	-	-	-	1.0000	0.2158	-0.3352	-0.1930
F_ΔMARGIN[j]	-	-	-	-	-	-	-	-	-	1.0000	0.3858	-0.0355
F_ΔTURN[k]	-	-	-	-	-	-	-	-	-	-	1.0000	0.1719
F_SCORE[l]	-	-	-	-	-	-	-	-	-	-	-	1.0000

NOTE: The definitions used in the above correlation analysis are consistent with Panel A.

The results presented in Table 2 reflect the relationships between the various F_Score underlying measures, the 3-month subsequent return and the composite F_Score. Panel A summarises the Spearman correlation analysis for the entire security universe over the selected period of study. Initial results indicate that the F_Score is the variable with the strongest relationship with subsequent 3-month returns (3M RETURN), although the positive correlation is weak (0.0753). Furthermore the F_Score is in fact negatively correlated with two of its underlying signals (F_ΔLEVER and EQ_OFFER). This is interesting as one would expect positive correlations between the composite score and its underlying signal. The existence of these negatively correlated relationships warrants further analysis to ensure that these signals are not incorrectly specified, however this is beyond the scope of this study.

Panel B presents the results of the High F_Score portfolio's correlation analysis. The panel highlights that on raw return basis, the F_Score does a relatively poor job at predicting subsequent 3-month returns. This is evident as both F_ΔROA (0.3875) and F_ΔTURN (0.3019) have higher correlations to subsequent 3-month returns, relative to the F_Score variable (0.2405). However, when the 3-month returns were converted to market-adjusted returns (3M MA RETURN), the F_Score delivered the highest correlation. This suggests that the F_Score variable is the best predicting variable for future 3-month returns, and is more effective as a predictive variable for market-adjusted returns relative to any of its underlying signals.

The intention of this study was essentially to determine whether it would be possible to use the Piotroski F_Score as an investment strategy over the long term. As the effectiveness of the F_Score in differentiating firm financial strength has been concluded to be statistically significant within the South African context, the cumulative returns were calculated for the respective F_Scores. The cumulative returns of the various F_Score categories are summarised in Table 2 and clearly indicate the effectiveness of the F_Score investment strategy over the period January 2004 to December 2012. Over the period, the long-only high F_Score portfolio generated an annualised return of 42.9% versus the low F_Score portfolio 20.3% and therefore delivered a return differential of 22.6%. Similarly, the high F_Score outperformed the equally-weighted market portfolio (29.8%) and market-capitalisation market portfolio (27.0%) by +13.0% and +15.9% respectively. Another interesting observation of the high F_Score portfolio is that its standard deviation (21.6%) was lower than all the other portfolios except for the market-capitalisation market portfolio (21.1%). This finding violates the traditional CAPM framework as higher returns are effectively being generated at lower levels of risk. Another interesting observation relates to the returns generated by the F_Score categories 7 and 8-9, whereby both generated returns above that of the high F_Score portfolio. The lower return is presumably as a result of the diversifying effect of having a greater number of

securities in the high F_Score portfolio as compared to its two underlying F_Score categories. This could be confirmed by the fact that the annualised standard deviation of the high F_Score portfolio is lower than that of both the F_Score 7 and 8-9 categories by 1.34% and 1.03% respectively.

Given the results of the test used to establish the effectiveness of the F_Score within the South African context, the next step was determine whether the F_Score's ability to differentiate between firm financial strength was still statistically significant even after accounting for firm size. Table 3 illustrates the results of F_Scores calculated and portioned according to firm size. The firms were ranked quarterly into their respective tercile according to firm market capitalisation. The results of the t-tests performed on the 3 various universes concluded that the long-only high F_Score portfolio market-adjusted returns were statistically significant at the 5% level to the low F_Score portfolio for both the Small-Cap and Mid-cap, however not for the Large-Cap. Similarly, the high F_Score portfolio market-adjusted returns were statistically significant at the 5% level to the overall market portfolio for both the Small-Cap and Large-cap, however not for the Mid-Cap. The fact that the Small-Cap high F_Score is statistically significant against both the low F_Score and market portfolios would suggest that the relationship is strongest in the small-cap firm universe. The conclusion is consistent with the findings of the Piotroski (2000) whereby the study found that the F_Score investment strategy was biased towards smaller firms as those firms tended to have lower share turnover and poor analyst coverage.

Given the strong performance achieved by the High F_Score portfolio over the period, the question moves to how straightforward would the replication of this methodology be in practice. Due to the fact that all the firm financial information required is in fact publicly available data, the success of the replication these results in practice, would primarily be dependent on execution costs. Table 4 presents a scenario analysis summary of the above mentioned high F_Score investment strategy and a similar strategy considering only firms with an F_Score of 8 or 9 for inclusion into a high F_Score portfolio (High 8-9 portfolio). The results clearly indicate that after assuming the 16 average trades per quarter, which are required to execute high F_Score long-only strategy, the effectiveness of the strategy is quickly eroded as a result of trading costs. At equilibrium, the entire excess return generated by the High F_Score portfolio, is eroded by assuming a per trade cost of 15 basis points. Following on from this, Table 4 also indicates the benefit of the fewer trades required by the High 8-9 portfolio, which even assuming a per trade fee of 0.50%, still delivers a market-adjusted return of 6.73%.

Table 3: Risk/Return Summary of the long-only 3-month investment strategy implemented over the period 2004 to 2012.

The table below summarises the respective investment strategies which could be followed by an investor. The returns are calculated by following a long-only approach assuming zero cash holding and quarter rebalancing with zero trading costs. Both the standard deviation and return numbers (excluding the quarterly average) have been reported on an annualised basis.

F_Score	Standrad Deviatiation	Annualised Return	Quarterly Average	Alpha[a]
0-1	n/a	n/a	4.92%	n/a
2	25.22%	20.13%	5.40%	-9.71%
3	24.45%	23.77%	6.13%	-6.08%
4	22.35%	28.31%	7.01%	-1.53%
5	23.75%	31.59%	7.76%	1.75%
6	22.78%	30.16%	7.41%	0.32%
7	22.99%	43.71%	10.09%	13.86%
8-9	22.68%	44.76%	10.27%	14.91%
F_Score 3-6	22.18%	28.71%	7.08%	-1.13%
F_Score 0-9	21.88%	29.84%	7.30%	0.00%
Market	21.13%	26.98%	6.72%	-2.87%
High F_Score	21.65%	42.88%	9.86%	13.03%
Low F_Score	22.81%	20.27%	5.32%	-9.57%
High less Low	-1.16%	22.60%	4.55%	
High Less All (0-9)	-0.23%	13.03%	2.57%	
High Less All (Market)	0.52%	15.90%	3.14%	

[a] The Alpha column is calculated as the as the F_Score annualised portfolio return less the market return (F_Score 0-9). This market-adjusted return is considered to be the opportunity cost of not following a passive index tracking investment strategy. The market-cap weighted market return is the return of a portfolio held in identical proportions to that of the FTSE/JSE.

Table 4: Quarterly Market-Adjusted Returns partitioned using Firm Size

The table presents the results of the F_Score strategy partitioned into small, mid, and large-cap firms. The firms are ranked on a quarterly basis according to firm market capitalisation and are then allocated into terciles. All previous descriptions and definitions are consistent with prior tables.

	SMALL-CAP FIRMS			MID-CAP FIRMS			LARGE-CAP FIRMS		
F_Score	**Mean**	**Median**	***n***	**Mean**	**Median**	***n***	**Mean**	**Median**	***n***
0 - 1	0.0208	-0.0135	56	-0.0178	-0.0266	39	0.0007	-0.0041	18
2	0.0010	-0.0361	177	-0.0576	-0.0643	91	-0.0040	-0.0179	80
3	-0.0129	-0.0341	277	-0.0120	-0.0184	264	0.0063	-0.0053	248
4	-0.0012	0.0049	434	0.0038	0.0059	468	-0.0068	-0.0044	406
5	0.0018	0.0052	372	0.0126	0.0149	444	-0.0056	-0.0062	422
6	-0.0054	-0.0085	316	0.0012	-0.0012	309	-0.0018	0.0065	360
7	0.0593	0.0630	120	0.0237	0.0332	174	0.0196	0.0145	282
8 - 9	0.0068	0.0229	47	0.0275	0.0194	67	0.0318	0.0152	119
3 - 6	-0.0041	-0.0028	1 399	0.0003	0.0002	1 485	-0.0032	-0.0029	1 436
0 - 9	-	-	1 799	-	-	1 856	-	-	1 935
High F_Score	0.0526	0.0287	167	0.0215	0.0211	241	0.0175	0.0115	401
Low F_Score	-0.0047	-0.0248	233	-0.0426	-0.0490	130	-0.0120	-0.0134	241
High less Low	0.0573	0.0535		0.0641	0.0701		0.0295	0.0249	
High Less All	0.0526	0.0287		0.0215	0.0211		0.0175	0.0115	

t-Test: Two-Sample Assuming Unequal Variances - 5% Significance Level

	P(T<=t) one-tail	P(T<=t) one-tail	P(T<=t) one-tail
High less Low	0.0078846	0.0157364	0.0673607
High less All	0.0005135	0.1137120	0.0468752

NOTE: The 3 different firm size categories were determined by ranking the all firms in the universe by market capitalisation, on a quarterly basis, and then allocating the firms into terciles depending on rank.

Table 5: F_Score Investment Strategy Returns after adjusting for trading costs

The table below represent an analysis of trading costs and its impact on the overall profitability of the F_Score investment strategy as described in the methodology section. The Average Trades column reported in the below tables, is the average number of new buy or sell trades required by the investment strategy on a quarterly basis. The average number of trades as represented below does not include any effect of rebalancing the portfolio to optimal equal weightings. The tables represent a scenario analysis of the effect of trading costs on the cumulative return over the investment period.

Panel A: High F_Score portfolio Market-Adjusted Annualised Returns including Transaction Costs

		Returns Excl. Trading Costs	
Portfolio	Average Trades	Gross Return	Market-Adjusted
High F_Score	16.2	42.88%	13.04%
0 - 9	n/a	29.84%	0.00%
		Returns Incl. Trading Costs	
Trading Costs		Net Tading Costs	Market-Adjusted
0.05%		38.67%	8.83%
0.10%		34.56%	4.72%
0.15%		30.53%	0.69%
0.20%		26.60%	-3.24%
0.25%		22.75%	-7.09%
0.30%		18.98%	-10.86%
0.35%		15.30%	-14.54%
0.40%		11.71%	-18.14%
0.45%		8.19%	-21.65%
0.50%		4.76%	-25.08%

Panel B: F_Score 8 – 9 portfolio Market-Adjusted Annualised Returns including Transaction Costs

		Returns Excl. Trading Costs	
Portfolio	Average Trades	Gross Return	Market-Adjusted
8 - 9	3.1	44.76%	14.92%
0 - 9	n/a	29.84%	0.00%
		Returns Incl. Trading Costs	
Trading Costs		Net Tading Costs	Market-Adjusted
0.05%		43.93%	14.08%
0.10%		43.10%	13.25%
0.15%		42.27%	12.43%
0.20%		41.45%	11.61%
0.25%		40.63%	10.79%
0.30%		39.81%	9.97%
0.35%		39.00%	9.16%
0.40%		38.19%	8.34%
0.45%		37.38%	7.54%
0.50%		36.57%	6.73%

4.2. Evidence of the use of the Piotroski F_Score by Institutional fund managers

In an attempt to not bias the study, the equity funds' entire underlying equity securities were used instead of simply only using the securities initially used to test for the effectiveness of the Piotroski F_Score methodology within the South African context. As a result of this the F_Score methodology as discussed previously, was applied to the equity manager security universe for the selected period. The results of this analysis are summarised in Table 6 and illustrate that the high F_Score long-only strategy is still statistically significant against both the market and low F_Score portfolio even over the significantly shorter time period. These results are consistent with prior results for which only shares within the cumulative 99% percentile of market capitalisation were considered. Even though this period is a subset of the overall study, and as such these results should come as a surprise, the underlying securities in the equity manager universe were distinctly different from the initial study and therefore provide further support for the effectiveness of the F_Score strategy on the FTSE/JSE.

Given that the F_Score methodology was statistically confirmed to be effective at generating superior returns above the market return, the Fund_Scores were calculated for each of the equity funds on a quarterly basis over the selected period. The Fund_Scores calculated unfortunately all fell between a maximum range of 3.86 and 5.44. The result of which meant that the grouping Fund_Scores into categories similar to that of the F_Scores would not provide any meaningful inference. Graph 1 illustrates the relationship between the Fund_Score value and its subsequent return using a scatterplot graph. All observations were plotted on the graph and a linear regression was run to establish whether there was any linear relationship present. The result of the linear regression suggests that there is no meaningful relationship between the level of the Fund_Score and its subsequent quarterly return. This is clearly evident by the regression line's R2 value of 0.01. Furthermore, the average Fund_Score was 4.65 with a maximum range for the period of 3.86-5.44, and when this is compared to the equally-weighted firm universe F_Score (4.60), it is clear that the difference between the two average quarterly F_Scores is negligible at 0.05. The fact that the maximum range of the fund manager Fund_Score is between the 3-6 F_Score range suggests that there is little use in relying on the Fund_Scores in determining future fund performance and that results have a higher probability of being misleading. Furthermore the range of the fund manager's Fund_Scores also suggests that portfolio construction is made without the consideration of an F_Score measure or equivalent. The result of the analysis supports the inference that equity fund managers, in South Arica on aggregate, do not tilt their portfolios towards firms with high F_Scores.

Table 6: Buy-and-Hold Portfolio Market-Adjusted Returns for an F_Score Investment Strategy with Annual Rebalancing (Equity Manager Security Universe)

The below table summarises the results of an annually rebalanced investment strategy which is centred on the F_Score methodology without the use of the book to market ratio as a screening criterion. The methodology and specific F_Score calculations are consistent with the results presented in Table. The period selected for the below results is December 2009 to December 2012

F_Score	Mean	10%	25%	50%	75%	90%	% Positive	*n*
0 - 1	-7.02%	-23.98%	-18.27%	-13.27%	-10.61%	-9.95%	16.67%	96
2	-4.73%	-10.63%	-10.12%	-7.98%	-6.43%	-5.91%	8.33%	227
3	-2.25%	-9.35%	-6.62%	-5.52%	-4.05%	-3.67%	16.67%	433
4	0.88%	-3.34%	-2.42%	-0.84%	0.02%	0.25%	75.00%	651
5	-0.34%	-4.19%	-2.94%	-1.97%	-1.14%	-0.88%	50.00%	610
6	3.09%	-1.95%	-0.41%	0.71%	1.73%	1.98%	83.33%	489
7	2.49%	-2.19%	-1.14%	0.23%	1.30%	1.75%	83.33%	321
8 - 9	0.76%	-5.92%	-3.93%	-2.09%	-0.68%	-0.23%	66.67%	158
3 - 6	0.37%	-1.32%	-0.66%	-0.26%	0.03%	0.14%	75.0%	2183
0 - 9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2985
High F_Score	1.96%	-1.11%	-0.87%	0.31%	1.16%	1.40%	75.0%	479
Low F_Score	-5.44%	-12.03%	-9.81%	-8.02%	-7.07%	-6.74%	8.3%	323
High less Low	7.40%	10.92%	8.94%	8.33%	8.23%	8.14%		
High Less All	1.96%	-1.11%	-0.87%	0.31%	1.16%	1.40%		

t-Test: Two-Sample Assuming Unequal Variances - 5% Significance Level

	P(T<=t) one-tail	t Stat	t Critical one-tail
High less Low	0.00001983	5.602699	1.745884
High less All	0.00372282	3.271476	1.795885

This finding is consistent with the finds of Zhou and Tice (2011) whereby it was concluded that US equity mutual fund managers do not slant their portfolios towards high F_Score firms.

Given the disappointing results of the Fund_Score, this study has also looked at determining whether there is any possible relationship between the Fund_Score of a fund manager and its subsequent performance relative to the universe. Funds were therefore grouped into quartiles depending on their respective quarterly Fund_Score from which equally-weighted subsequent quarterly quartile performance was calculated. Surprisingly there was the evident relationship that the subsequent average quarterly performance of the high Fund_Score quartile was higher than the low Fund_Score quartile. More specifically, the 1st quartile (+3.74%) and 4th quartile (+2.41%) average subsequent quarterly returns translate into a return differential of 1.34% over the analysed period. Equally interesting, the returns generated by the 1st quartile portfolio of funds managed to outperform the market 83.3% of the time relative to the 4th quartiles mere 33.3%.

The results of this analysis are represented in Table 7. On average manager-adjusted return basis, the 1st quartile portfolio of funds consistently outperforms both the average manager and 4th quartile portfolio returns. As such the 1st quartile portfolio returns are also considered statistically significant at the 5% level given the consistent outperformance. It should however be noted that there were only effectively 12 quarterly observation available for this t-test, and as such the results should be confirmed over a longer period in order to confirm the robustness of this apparent relationship.

Graph 1: Scatterplot Diagram of Quarterly Equity Manager Fund_Scores and Subsequent Returns

The Fund_Score is the market–value weighted aggregate F_Score of all the underlying shares held by an equity manager. The graph plots quarterly equity manager Fund_Scores on the x-axis and subsequent returns on the y-axis. The equation presented on the graph represents a linear regression equation with the Fund_Score as the independent variable and the subsequent return as the dependent variable. The linear regression's R^2 value and trend line have also been included on the graph.

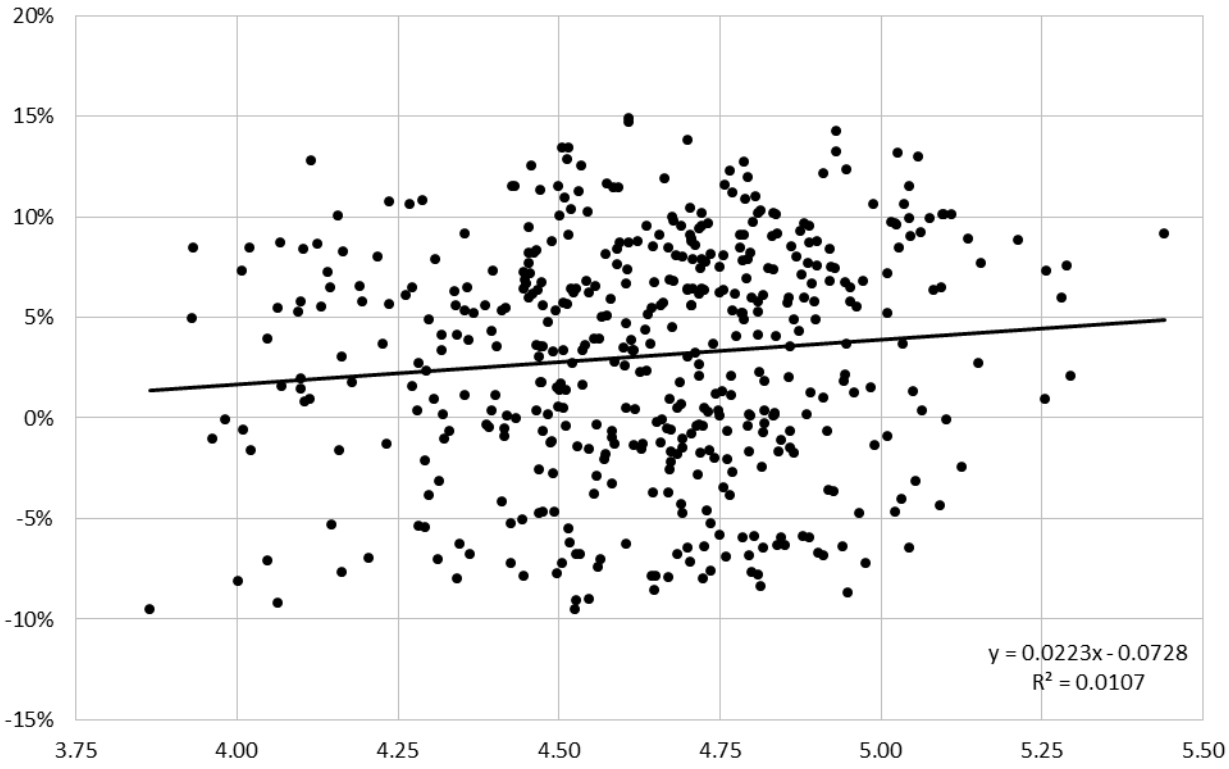

Table 7: Equity Manager Returns partitioned into quartiles

This table provides a returns summary of the equity manager universe which was partitioned into quartiles according to Fund_Score. The quartiles were rebalanced quarterly and any equity fund which had insufficient quarterly data was omitted from the universe for the period December 2009 to December 2012.

Quartile	Mean	10%	25%	50%	75%	90%	% Positive	*n*
1st Quartile	0.0066	-0.0023	0.0003	0.0025	0.0037	0.0046	83.3%	119
2nd Quartile	0.0028	-0.0067	-0.0052	-0.0022	-0.0003	0.0003	66.7%	121
3rd Quartile	-0.0026	-0.0183	-0.0117	-0.0084	-0.0055	-0.0047	33.3%	125
4th Quartile	-0.0068	-0.0198	-0.0182	-0.0139	-0.0097	-0.0085	33.3%	123
Average	-	-	-	-	-	-	n/a	488
1st less 4th	0.0134	0.0174	0.0185	0.0164	0.0133	0.0131		
1st less Ave	0.0066	-0.0023	0.0003	0.0025	0.0037	0.0046		

t-Test: Two-Sample Assuming Unequal Variances - 5% Significance Level

	P(T<=t) one-tail	t Stat	t Critical one-tail
1st less 4th	0.0001	4.446187	1.724718
1st less Ave	0.0016	3.757801	1.795885

5. CONCLUSIONS

In this paper, I find that the Piotroski F_Score methodology has merit as an investment strategy on South Africa's FTSE/JSE. The methodology of the F_Score used in this study has deviated somewhat from the original assumptions used by Piotroski (2000) and similarly Atwood (2012). The F_Score strategy aims to use fundamental firm information to determine whether individual firms are improving or deteriorating in financial strength in an effort to identify which firms are more likely on average to outperform the market in the following period. There are two primary changes to the original F_Score methodology, namely the use of quarterly rebalancing and the omission of the book-market (BM) ratio as a screening criterion for portfolio construction. The quarterly rebalancing assumption allowed for a greater number of data points to be collected as opposed to the annual rebalancing. The BM ratio was also not used as a traditional screening criterion for the high F_Score portfolio due to the fact that the FTSE/JSE is dominated by large-cap stocks. The result of this market characteristic is that the at the 99% cumulative market capitalisation level, there is a quarterly average of only 168 stocks which have the necessary financial information required to calculate their respective F_Scores. Therefore given this unique emerging market characteristic, the BM ratio screen was ignored in similar fashion to a study performed by Zhou and Tice (2011) and as such allowed for high F_Score portfolios to be constructed with investment opportunities in all quarters and with an average number of holding 23.

The results of this study clearly illustrate that the F_Score strategy is both statistically significant in generating equity returns above that of the general market and can be implemented without having to rely on the book BM as a selection criteria during portfolio construction. The quarterly rebalancing F_Score approach used in this study resulted in an average quarterly return of 9.86% for the High F_Score portfolio. The high F_Score portfolio outperformed the market and low F_Score portfolios by 2.78% and 4.55% respectively, and over the entire holding period of the study (2004-2012), the high F_Score portfolio generated an annualised return of 42.9% versus the market portfolio's return of 29.8% on a total return basis. All returns were calculated before the effects of trading costs unless explicitly stated otherwise. The high F_Score also managed to outperform the market portfolio 74% of the time in contrast to the low F_Score portfolio which underperformed the market 77% out of all quarterly observations.

There were further interesting findings when I controlled for the firm size effect on the portfolios. The results indicated that the F_Score relationship of a high F_Score portfolio generating average quarterly returns above market and low F_Score portfolios is evident for small, mid and large-cap firms alike. The small-cap firm universe was statistically significant for the high F_Score market adjusted returns relative to the market and low F_Score returns. Whilst both the mid and

large cap universes clearly illustrated that the strategy could generate returns above the market and low F_Score portfolios, unfortunately both the mid and large-cap high F_Score strategies proved to not be statistically significant at the 5% level against the market portfolio and the low F_Score portfolio respectively. While this result does highlight that the F_Score strategy appears to be strongest in the small-cap firm universe, it is however consistent with the findings of Piotroski (2000) whereby the study found that the F_Score strategy is biased towards small-cap stocks as a result of their low analyst coverage and infrequent trading.

After having proven that the F_Score could be used effectively as investment strategy to generate abnormal returns above the market, I replicated 12-month holding period performed by Atwood (2012) in an attempt to compare whether the high F_Score strategy could be proved to be statistically significant over a longer time period and without the constraint of using only firms with a high BM ratio. The results confirmed that the high F_Score strategy was statistically different form that of the market and the low F_Score portfolios at the 5% level. It is however important to note that in an attempt to increase the number of quarterly observations, 4 different start date portfolios of equal investment periods were used to derive the statistics which were used to draw the above inferences.

These results are in contrast to the Atwood (2012) study which concluded that whilst the high F_Score and high book-market portfolio outperformed the low F_Score and market portfolios, it was however unfortunately not statistically significant. Reasons cited in the study for the unfavourable outcome primarily circled around the lack of publicly historical financial firm data available for the FTSE/JSE. This study was constructed using quarterly data with a similar methodology to Zhou and Tice (2011) in an attempt to significantly increase the number of data points available for analysis. This studies finding were however also consistent with another replication study by Hyde (2013) which found the F_Score methodology to be statistically significant (at the 1% level) on the FTSE/JSE.

The practical application of the Piotroski F_Score investment strategy, as performed by this study, is an important consideration in order to establish it's effective for actual investors. The results of the below scenario analysis, as presented in Table 4, clearly indicates that the practical application of the Piotroski F_Score will be significantly affected by transaction costs, assuming its current quarterly rebalancing form. The conclusion of this finding is twofold, firstly the quarterly rebalancing approach as highlighted in this study is better suited to institutional investors who are able to minimise transaction costs, and secondly that should an individual investor wish to maintain quarterly rebalancing, they would need to incorporate further portfolio filtering so as to reduce the

average number of quarterly trades to a point whereby there is an equilibrium between transaction costs, the benefits of diversification, and the number of trades regularly executed.

The final results of this study relate to my attempt to try and establish whether there was any relationship present between the methodology used in the F_Score investment strategy and those that are employed by sophisticated investors within the South African context. Institutional equity managers' form the ASISA General Equity category was used to compare the respective funds' net asset value weighted overall F_Score (Fund_Score). The results of the Fund_Score analysis for the fund universe clearly indicated that South African equity managers do not use the F_Score investment strategy in any meaningful manner in an attempt to generate returns. The maximum Fund_Score range for the 3 year period of analysis was only 3.86 to 5.44, with an average of 4.65, and as such was never in the original high or low F_Score portfolios. The final test was to establish whether fund managers with a higher Fund_Score relative to its peers would subsequently achieve greater returns over the following period. The funds where quarterly ranked by their Fund_Score and then allocated to a quartile which resulted in four portfolios rebalanced quarterly over the 3 year period which the manager detail was available for. The study indicated that the 1st quartile of fund managers (high Fund_Scores) consistently outperformed 4th quartile (low Fund_Scores) for all 12 available observations. Furthermore the 1st quartile portfolio of funds achieved an average quarterly excess return of 1.4% and 0.7% over the 4th quartile and overall universe respectively. Furthermore, assuming the investment strategy was followed for the 3 year period, the 1st quartile portfolio would have delivered an annualised return of 15.2% versus the manager average and 4th quartile portfolio returns of 12.3% and 9.4% respectively. The results were statistically significant, however given small number of data points, it would require a larger dataset to determine the robustness of these findings.

In concluding, this study has proven that there is substantial evidence to support the fact that it is possible to use an accounting-based fundamental analysis strategy to construct a portfolio that is able to shift the distribution of returns for an investor above what would be expect relative to a passive index portfolio. The F_Score is also proven to be effective and statistically significant at deliver excess-market returns on the FTSE/JSE. The study also highlights this modified version of the Piotroski F_Score methodology (quarterly rebalancing, no BM criteria) is effective over multiple time periods and appears to deliver robust results before trading costs are considered. Finally, the study also concludes that even with the presence of simple investment approach to generating excess returns, there is no sign that any South African equity managers tilt their portfolios towards high F_Score firms.

6. TOPICS FOR FURTHER RESEARCH

6.1. Piotroski F_Score

Given that this study needed to alter the original Piotroski (2000) F_Score methodology in order to allow for unique capital market characteristics in the South African, there is still scope for the F_Score strategy to be tested on the FTSE/JSE. An area which could be focussed on is running the original and/or this study's F_Score methodology over a longer period than simply the 9 year period used currently in order to determine whether the strategy is robust out of sample and over a longer term.

Table 2 also provides an opportunity for further study as it highlights the fact that the overall security universe is, on aggregate, negatively correlated to a firm's change in leverage (ΔLEVER) and change in shares outstanding (EQ_OFFER). The existence of these negatively correlated relationships warrants further analysis to ensure that these signals are not incorrectly specified, as this was beyond the scope of this study in particular.

Another important area which should be considered for additional research relates to this study's omission of the book-market ratio level as an investment criterion. Whilst the study clearly illustrated that the investment strategy was effective even without considering the level of the book to market ratio, additional research should be undertaken as to determine whether this approach is still optimal after having compared it to alternative approaches like that used in Mohanram (2005). Mohanram constructs portfolios using a G_Score and effectively accounts for the opposite spectrum of the book-market spectrum as compared to the original F_Score strategy.

6.2. Fund_Scores for Unit Trust Equity Managers

The results presented in this study are undoubtedly open to dispute given the relatively short period used to analyse the relationship between the Fund_Scores and subsequent performance. Unfortunately the data that was used was the only publicly available data free of charge. There are however a significant number of South African equity managers which have over 10 years of track record which could be used to analyse the findings of the is study and Zhou and Tice (2011) further within the South African context. Finally, one last area of possible future research could relate to trying to be understand what the various reasons may be that have resulted in equity managers not adopting the F_Score strategy in any meaningful manner. I expect that the reasons for this will be diverse and cover a host of possible areas such as liquidity and ownership constraints, market tracking error restrictions, and longer term investment horizons.

Finally, given the assumption that many equity managers in South African chose to invest with an investment horizon that aims to invest through the business cycle (3-5 years), it would not be

surprising to conclude that equity fund managers do not tilt their portfolios toward high F_Score firms. Therefore in an attempt to remove all the noise (investment horizon, ownership constraints, etc.) factors from a Fund_Score equity fund managers study, a study could be performed which analyses whether there is any relationship between a firms F_Score and its change in F_Score and the change in holdings of equity manager on a quarter-on-quarter. From this perspective, it could be possible to identify whether equity managers, in South Africa, buy financially improving firms and sell the deteriorating firm, which would be consistent with the F_Score methodology.

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