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On the Financial Determinants of the Piotroski F-Score: An Analysis of Borsa İstanbul Firms

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Abstract

This study investigates the factors effective on Piotroski F-score which is a proxy for financial health of the firms. Manufacturing firms operate in Borsa İstanbul are considered in the analyses with using the time period of 2017:Q1-2024:Q3. This study contributes to the literature by identifying financial determinants of Piotroski F-Score in Türkiye. Driscoll and Kraay (1998) estimator is used with fixed effect panel regression in order to handle issues of heteroscedasticity, cross sectional dependency and autocorrelation in the model. Altman Z-score, return on invested capital, market to book ratio, Tobin's Q ratio and Beneish M-score significantly impact Piotroski F-score. According to the regression results, companies with lower financial distress risks (higher Altman Z-score) are expected to have better financial health. Similarly, those with improved return on invested capital tend to exhibit stronger financial health. Moreover, firms with higher market-to-book ratios are generally more profitable, potentially leading to higher Piotroski F-scores, indicating better financial health. A higher Tobin's Q value suggests greater performance expectations from the company, which correlates with higher financial health. Conversely, a negative relation between the Beneish M-score and Piotroski F-score implies that companies with a higher likelihood of earnings manipulation tend to have weaker financial health.

Keywords: Piotroski F-score, Beneish M-Score, Altman Z-score Financial Health, Financial Performance, Borsa İstanbul, Panel Data Analysis

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1. INTRODUCTION

Investment in modern days has advanced to include more investment instruments, which has made it even harder for people to choose the right investment instrument. Notably, stock market investors look for several alternative companies to invest in since they would like to have a long-term vision. The main priority for portfolio investors, as stated by Anderson et al. (2021), is to establish an investment strategy that ensures consistent profitability. Numerous research studies have demonstrated that value stocks generally provide returns that exceed those offered by growth stocks. Evidence from US stock market data, as presented by Fama and French (1992), demonstrates that value stocks yield superior returns compared to growth stocks. Likewise, Asness et al. (2013) reveal, through the analysis of international stock market data, that value stocks consistently outperform growth stocks. Moreover, using international stock market data, Asness et al. (2013) prove that value stocks provide higher returns than growth stocks. Nevertheless, identifying suitable value stocks and developing a profitable value strategy are not easy tasks to accomplish immediately; they require time to understand and implement in specific situations. To address this issue, a model created by Piotroski (2000) can be employed to identify profitable stocks, which would make a profit when incorporated into a value stock portfolio. Piotroski maintains that this should be accomplished by changes to the fundamental principles of a company that utilize the historical financial statements of the company. Additionally, the use of historical financial statement data has been recommended because of the high prevalence of book to market companies that are typically under less analyst coverage, and thus, forecast information is not always accessible. The F-score, created by Piotroski (2000), has become popular as a simple, yet comprehensive, description of the financial health of an organization. The total number of 0/1 flags is used to describe the effectiveness of an organization's operations, their composition, and the changes in capital, profitability, and especially results, whether these qualities are increasing or decreasing (Walkshäusl, 2020; Rangapriya & Meenakumari, 2021). In the US stock market for the period 1976-1996, high-fidelity stocks that were below par were approximately 30% of the total market value, which was based on the book value of the stock and the annual return of the top 20% companies. The endeavor of Piotroski has been reproduced with positive results in the European stock market and the Asia-Pacific region, although not as pronounced as it is in the U.S. Also, robustness tests followed by Piotroski have confirmed its effectiveness on most small distressed firms, which often have low or no analyst coverage.

Piotroski F-score is no longer just a counting of gain or loss phenomenon in the investment decision-making process; rather, it comes out as a crucial supporting factor for investment decisions and future performance forecasting. The efficiency of the F-score has been supported by a study discerning between growing companies and those prone to financial distress. In a study, for instance, companies with a high F-score more often outperformed their counterparts with a lower score, implying an investment strategy advantage in terms of excess returns (He and Tan, 2022). Additionally, the F-score plays an important role in helping investors to find healthy firms and ‘read’ early warning signals of

potential distress. Value investing in strong F-scored stocks could be a healthy affair for investors and thereby channelizing their money into available growth opportunities with minimal risk exposure. Another benefit of the Piotroski F-score is for those investors who plan to stay invested for the long term. It helps them identify companies with strong financial fundamentals and the potential to perform consistently over time (Rangapriya & Meenakumari, 2021). So, Piotroski F-score has many areas of application, making it a much-needed tool for individuals who want to invest both in Türkiye and international markets to make the right choices in the confusion of financial matters. It allows investors who want to invest in manufacturing industry enterprises, which are the locomotive of an emerging economy like Türkiye, to shape their portfolios.

Piotroski F-score has been employed as a predictor of future profitability for companies and as an instrument to determine if the public's fundamental information is reflected in prices (Turtle & Wang, 2017). Piotroski and So (2012), Ahmed and Safdar (2018) demonstrate that the errors of investor expectations regarding the company's financial position, which are proxied through the F-score of Piotroski, lead to abnormal returns in the US stock market, as well as a premium for momentum. These effects are attributed to the company's financial position. Additionally, additional research shows that Piotroski's F-score is effective in other areas. Piotroski and So (2012), Ng and Shen (2016) demonstrate that the Piotroski F-score has the capacity to pre-sort Asian companies into subsequent winners and losers. Walkshäusl (2017) and Walkshäusl (2019) demonstrate that the Piotroski F-score is also involved in the understanding of the value and momentum effects in European stock returns that are associated with investors' misconceptions of fundamental issues. Ng and Shen (2020) demonstrate the existence of evidence on the market-wide Piotroski F-score and its association with the Australian and five Asian stock markets.

Piotroski F-score, one of the most applied financial indicators and primarily used in financial markets, has been tested in various capital markets, especially in determining financial health, financial distress or for the purpose of modelling a portfolio. However, there is not any study that tests the factors effective on Piotroski F-score. This study addresses a gap in the literature by examining the determinants of Piotroski F-score in the Turkish manufacturing sector. Although Tepeli and Kahraman (2023) considers Piotroski F-score as a proxy for financial success in Borsa İstanbul firms, they only investigate the impact of firm-specific debt structure ratios on financial success. Similarly, Karadeniz, and İskenderoğlu (2024a) examine the financial performance of lodging companies that are listed on Borsa İstanbul Hotels and Restaurants Sector through Piotroski F-score. Karadeniz and İskenderoğlu (2024c) examine the financial performance of health care companies traded in Borsa İstanbul Human Health and Social Work Activities Sector between 2020-2022 through Piotroski F-score. However, the current study takes into consideration various firm specific characteristics that might be effective on financial health such as Altman Z-score (Altman), return on invested capital (Roic), investment growth rate (Inv), price to earnings (PE) ratio, market to book (MB) ratio, enterprise value to net sales ratio (EV), Tobin's

Q ratio (Tobin) and Beneish M-score (Beneish). For this purpose, 2019:Q4-2023:Q3 data of 144 manufacturing industry companies traded in Borsa İstanbul are used. According to the empirical results Altman, Roic, MB, Tobin and Beneish variables are found to be effective on financial health of the manufacturing firms operating in Borsa İstanbul.

The next section presents the literature review related to the Piotroski F-score. Section 3 outlines the data and methodology used in this study. Empirical results are presented in Section 4, and the study concludes in the final section.

2. LITERATURE REVIEW

In recent finance literature, the Piotroski F-score has received much attention. Studies have explored the model's effectiveness using various variables across different nations' financial markets. Joseph Piotroski is attributed with creating and promoting the Piotroski F-score. In 2000, he releases a scientific article that described a strategy for investing in equity and demonstrated its effectiveness through his own research. The concept of the Piotroski F-score strategy is derived from a method that involves the utilization of certain fundamental features in order to achieve success in the stock market. Specifically, an investor can utilize information sourced from financial statements to reliably distinguish profitable firms “winners” from unprofitable ones “losers”. Piotroski has identified the financial statement elements for identifying the attractiveness of a stock that could be another step into value investing, which is already widely known and used (Piotroski, 2000; Piotroski, 2005). Meanwhile, numerous studies have shown its effectiveness; yet most of it rested on a good return from the shares of a few strong firms, while many other weak companies with unsatisfactory growth prospects had also to be considered simultaneously (Kusowska, 2021).

Based on Piotroski F-score, they are evaluated using high B/M stocks, but Mohr (2012) utilizes this score on growth stocks. The Piotroski F-score may be beneficial for creating market-average portfolios that yield high returns. Its utilization increases the explainability of multiple regression analysis regarding the association between return and variance in market conditions. In their research, Krauss et al. (2015) create a method of calculating the Piotroski F-score. They employ the Piotroski F-score in the US stock market from 2005 to 2010. Based on their findings from the time span of 2005 to 2015, individual investors who have minimal capital, like a few thousand US dollars, can consider applying the Piotroski F-score strategy. Nevertheless, one should be cautious about reported return figures because generally speaking, the brunt of those is taken out by market frictions.

An exploration into the global applicability of Piotroski F-score took place in countries such as Mexico and Finland. In Mexico, for instance, a comparison between Piotroski F-score and Ohlson Model is made using 63 Mexican stocks from 2005 to 2011. It has been found that Piotroski F-score is an effective financial tool revealing the current and historical financial stability of the organization. Another study, which examine the Finland stock market during the time span from 2004 to 2015,

construct portfolios based on Piotroski F-score because it is hypothesized that a higher Piotroski F-score might lead to higher risk-adjusted returns. As reported by Duran-Vazquez et al. (2014), the research report ends its review by indicating that their hypothesis prevails and has a positive impact on the investor's return. A study on the Piotroski F-score performance in the Indian stock market for 500 companies during 2010-2015 demonstrate that both a high Piotroski F-score and a high B/M ratio can help investors to shift their contemporaneous as well as future performances towards positive returns. In the study, they analyze how Piotroski F-score impacts stock projected returns, ROE (Return On Equity), M/B value ratio, dividend yield, and liquidity through a multiple regression model, which indicates that Piotroski F-score is one of the good indicators for equity investments (Tripathy & Pani, 2017). In a recent study conducted by Rangapriya and Meenakumari (2021), the focus is on examining the effectiveness of the Piotroski F-score as a means of identifying financially healthy companies and detecting early indications of financial distress within the Indian banking sector. All banks have Piotroski F-score ranging from 0 to 7, suggesting they are not compelling buys for the seven-year period. In some cases, some banks have revealed that Piotroski F-score continuously plummet for at least three years, and this may imply that financial trouble is approaching.

In 2024, Veeraraghavan undertakes an analysis of financial aspects of IT (Information Technology) companies that are listed on the National Stock Exchange of India on 15th August 2023. The research aims at analyzing the financial performance of these 99 companies on parameters such as revenue growth, profitability, solvency, market performance, and financial strength for the year ended March 31, 2023. The classification is based on income which resulted in four categories, namely: "very large"; "large"; "medium"; and "small". The financial strength of these companies is measured by the Piotroski F-score and the financial solvency by Altman Z-score. There are only 2 out of 17 companies in the "very large" and "large" group who possess a Piotroski F-score of more than 8, while as many as 10 out of 82 companies among Small and Medium Companies are with this score. Another research conducts an analysis on the stocks listed on the Bombay Stock Exchange, non-financial companies for 15 years starting from 1996 to 2010. It is suggested in this paper that investing based on Piotroski F-score allows for greater returns at risk-controlled levels (Singh & Kaur, 2015). After obtaining favorable findings regarding the investment style tests, more detailed studies are conducted with reference to individual sectors. Mesarić (2014) applies the Piotroski F-score to five automobile distributors from Croatia for the 2007-2012 period. The study is comprehensive and aimed at examining the financial performance of these firms as well as the health of the industry. The article establishes that Piotroski F-score acts as an advance warning signal of crisis. Thus, it is demonstrated to have added value for investors making investment decisions on a medium to long-term basis by revealing situations that may eventually lead to crises.

In an attempt to verify the statistical evidence of the Piotroski F-score efficiency and also because of its success, researchers become more enthusiastic about this matter. Walkshäusl (2020)

employes Piotroski's approach with modifications on sample type. In the same vein, from 2000-2018, Walkshäusl (2020) demonstrates how well the Piotroski F-score strategy works not only in developed countries that are not US-based but also in emerging markets. Tikkanen and Äijö (2018) also conducts another study which aimed at assessing the effectiveness of Piotroski F-score as one of the value investing strategies. To collect the required data, the experiment considered European companies throughout the period between 1992 and 2014. In their research, the authors considered B/M, EBIT/EV, EBITDA/EV, earnings divided by market capitalization, dividends to market capitalization, and Novy Marx profitability ratio. The implementation of the Piotroski F-score strategy has been found to significantly increase profits for all value investing strategies in this research; however, it is found most effective in the case of a company with an EBIT/EV ratio.

In the capital market of Polonia, investigation of the Piotroski F-score strategy has been extensive. The most recent study, which investigates the effectiveness of this method in the Polish stock exchange, is completed by Pilch (2021), Kusowska (2021), Pilch (2023a), and Pilch (2023b). The time period considered is from 2017-2020, and it concerns a sample of 54 companies in the IT and video game industries. In his research, Pilch (2021) advocates the Piotroski F-score method of identifying companies that have a significant financial foundation that promotes high returns on investments in the Warsaw Stock Exchange. Pilch documents that the strategy of the Piotroski F-score is still effective after several years since its original publication. Kusowska (2021) attempts to assess the effectiveness of the Piotroski F-score method based on the example of the Warsaw Stock Exchange from 2014 to 2020. The investigation revealed that, using financial statement analysis in the value investing method, returns can be increased for investors. Additionally, it has been observed that the Piotroski F-score analysis is more successful than simply purchasing the WIG30 index. Additionally, portfolios that comprised of companies with high F-scores for Piotroski are superior to those that comprised of companies with low F-scores. The research conducted by Pilch (2023a) seeks to create models similar to Piotroski F-score that base their data on information from the Polish stock exchange. The time period considered is from 2012-2022. However, models that included the X-score and Y-score are found to be less effective than the Piotroski F-score. Additionally, these models produce negative returns with raw and market-based. Conversely, the utilization of Piotroski F-score is considered purposeful, as it can produce a mean annual revenue-boosted return of 1.35%. Other models of scoring are also considered, but this research only demonstrates partial support for the high B/M strategy. The effectiveness of Piotroski F-scores like models is evaluated by Pilch (2023b) on the instance of the stock market of Poland. As a result, attention is devoted to models like PiotroskiTrfm and FS-score that are associated with Piotroski F-score. It is observed that companies with higher rankings had higher raw and average positive returns. However, these returns are less than the average return of low-scoring companies (for the FS score) or the entire high B/M portfolio. The findings of the study indicate that Piotroski F-score, FS-score, and Piotroski Trfm are generally beneficial tools for investments.

To assess the ability of the Piotroski F-score model to predict financial distress among the Tehran Stock Exchange-listed companies, Khalilian (2024) aims to provide a study. According to the study results, it is evident that there is a significant negative relation between the Piotroski F-score and the likelihood of financial distress, meaning that the Piotroski F-score model does well to identify weak firms so that these companies can avoid bankrupting themselves by making proper decisions. Based on the work of Hyde (2016), adopting the Piotroski F-score as an indicator to reveal the state of stocks with a favorable financial condition allowed the maximum return from investments. The test is conducted on S&P 500 and ASX 200 shares. It has been said in the article that more investigation of the Piotroski F-score connection with other variables could enhance its information content value and contribute to market participants receiving more reliable signs of financial distress. Xue (2022) focuses his research on the efficacy of a fundamental strength measure Piotroski F-score in the Shanghai A-share index. The results reveal that Piotroski F-score is able to anticipate short-term and medium-term profitability. Accordingly, Piotroski F-score can be seen as an innovative and standalone fundamental strength measure applicable to Chinese stock market. Buren et al. (2024) perform research that concerned 61 stocks on the Mongolian Stock Exchange within the period of 2011-2022. As a result, book value and Piotroski F-score are positively significant drivers of closed share prices. In Karadeniz and İskenderoğlu's (2024b) research, the financial strengths of 24 football clubs from the six national leagues under the Union of European Football Associations (UEFA) are investigated by the Piotroski F-score technique to analyze football clubs' financial strength at the international level. According to the F-score values, it is discovered that the financial strengths of football clubs were in an average position and they are considered investable entities. In terms of average F-score values, it is seen that Bayern Munich and also Sporting Lisbon made the best performances on this score while Lazio and AS Roma are the least successful football clubs. On the basis of the averages of nine financial indicators, the three most successful financial indicators are change in paid-in capital, earnings quality and cash flows from operating activities. The three least successful financial indicators are asset profitability, change in leverage and change in gross profit margin.

In research that is performed in the area of the Turkish capital market, Tepeli and Kahraman (2023) are interested in determining if borrowing levels and financial performance can be correlated. Based on the assessment conducted on the BIST All Shares index, it has been observed that short-term trade debts contribute significantly and positively to the Piotroski F-score; however, no relation is discovered between them and other variables. A different study conducted by Gökten et al. (2021) aim to explore the role of book value as a mediator between financial performance and market value. To measure financial performance, the researchers utilize Piotroski F-score indicators instead of relying solely on a single earnings proxy. The dataset use for this study includes quarterly accounting data and prices of publicly traded companies listed on Borsa İstanbul between 2009 and 2015. Findings from the model reveal that book value has a negative mediator effect which has disrupted the simple relation

between financial performance and stock value. Karadeniz and İskenderoğlu (2024a) have computed nine financial ratios concerning profitability, liquidity-leverage, and operating efficiency of the companies for the years 2018-2022 in order to analyse the financial performance of companies that were listed on Borsa İstanbul Hotels and Restaurants Sector as per the Piotroski F-score. Returns on companies' stocks have been tabulated for the period of 2019 to 2023 to appraise the forecasting efficacy of Piotroski F-scores of companies as concerns present and one-year lagged future performances. The most successful variable in the accommodation companies is the change in paid-in capital, while the least successful variable was the change in asset turnover. Finally, high F-scores for accommodation companies' stocks inside the portfolio reportedly outperformed those portfolios with lower F-scores in both the current year as well as the deferral period. In their research, Karadeniz and İskenderoğlu (2024c) use the Piotroski F-score to analyze the financial performance of health companies whose shares were traded in Borsa İstanbul Human Health and Social Work Activities Sector for the period 2020-2022. Almost entirely it is concluded that their financial performance was of a moderate nature according to the Piotroski F-scores and hence warrant for investment. Through this analysis, it is obviously seen that vitality and profitability, and main activities cash flows forms the best financial indicators of the companies under Piotroski F-score, but everyone failed in earnings quality indicator and main activities' cash flows are less than net profit figure.

With respect to the period studied and variables examined, findings from these studies reveal the usefulness of Piotroski F-score strategy. A number of studies substantially broaden Piotroski's original results. The appeal of this strategy to researchers is evident in its high returns and simplicity.

3. DATA AND METHODOLOGY

3.1. Data

This study examines the factors affecting the Piotroski F-score of manufacturing firms operating in Borsa İstanbul. 2017:Q1-2024:Q3 data of 144 manufacturing industry companies traded in Borsa İstanbul are used. The data for dependent and independent variables is collected from Finnet Stock Expert Database. While Piotroski F-score is the dependent variable, Altman Z-score, return on invested capital, investment growth rate, price to earnings ratio, market to book ratio, enterprise value, Tobin's Q ratio and Beneish M-score are the independent variables. The definition of these variables are as follows:

Piotroski F-score (Piotroski): The F-score, introduced by Piotroski in 2000, is a measure that combines nine binary indicators, each assigned a value of either 0 or 1. These indicators assess various aspects of a company's financial health. Among these indicators, four-gauge profitability, three assess liquidity, and two measure operating efficiency. For each indicator, a value of 1 represents strength, while 0 indicates weakness. By summing up these indicators, the F-score yields a score ranging from 0 to 9. Higher scores indicate better financial performance or quality (Lalwani & Chakraborty, 2018).

A total of 9 criteria are used to calculate the Piotroski F-score, which are further split into 3 groups (He & Tan, 2022):

Profitability;

1. Return on Assets (ROA) (F-score is assigned a value of 1 when ROA is positive, and 0 otherwise)
2. Operating Cash Flow (CFO) (If CFO is positive, F-score is 1, and 0 otherwise)
3. Change in Return of Assets (ROA) (F-score is 1 if ΔROA is larger than zero; otherwise, F-score will be zero)
4. Accruals (If CFO is greater than ROA, F-score will equal 1; otherwise, F-score will be 0)

Leverage, Liquidity and New Issuance;

1. Change in Leverage (long-term) ratio (1 point awarded if the ratio decreases from the previous year, 0 points if it remains the same or increases)
2. Change in Current ratio (1 point awarded if the ratio decreases from the previous year, 0 points if it remains the same or increases)
3. No new shares were issued in the last year (lack of dilution) (1 point): Changes in paid-in capital are analyzed to identify the occurrence of a rights issue, which helps in detecting potential share dilution.

Operating Efficiency;

1. Change in Gross Margin (If F-score for a company is equal to 1, this means that the current year's ratio minus the prior year's ratio is greater than zero; otherwise, it equals 0)
2. Change in Asset Turnover ratio (If the current year's ratio minus prior years is greater than 0, then F-score is equal to 1; if not, it is equal to 0)

Altman Z-score (Altman): This variable is a proxy for the possibility of financial distress. Altman (1968) calculates the Z-score with the following formula:

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5 \quad (1)$$

where

X_1: Working capital/Total assets

X_2: Retained Earnings/Total assets

X_3: Earnings before interest and taxes/Total assets

X_4: Market value equity/Book value of total debt

X_5: Sales/Total assets

Return on Invested Capital (Roic): The return on invested capital in a company seeks to gauge the profitability generated from the capital put into an investment. It is calculated as follows (Damodaran, 2007):

$$ROIC = \frac{Operating\ income\ _t(1-tax\ rate)}{Book\ value\ of\ invested\ capital_{t-1}} \quad (2)$$

ROIC assesses how well a company utilizes its capital to generate profits. It gauges the efficiency of capital investments by analyzing the returns generated from both debt and equity. This assessment evaluates the company's capacity to achieve success, secure financing, meet its financial obligations, and provide returns to its shareholders. A higher ROIC suggests that the company is making more profit for each dollar invested, signaling strong operational performance and effective management (Puspitasari et al., 2023).

Investment Growth Rate (Inv): It is the percentage growth of a company's investment compared to the previous period.

Price to Earnings Ratio (PE): This variable is the ratio of market price per share to the earnings per share.

Market to Book Ratio (MB): It is the ratio of the market value of a firm's stock to its book value.

Enterprise Value Ratio (FV): This variable is calculated by dividing the value of a firm to its net sales revenue.

Tobin's Q Ratio (Tobin): This variable is the ratio of total market value of a firm to the replacement cost of firm's assets. If Tobin's Q is less than 1, it suggests that the market values the company lower than the total value of its assets. Conversely, if Tobin's Q is greater than 1, it indicates that the market values the company higher than the sum of its assets. Therefore, higher Q ratios imply that the market assigns a higher performance expectation to the company (Lewellen & Badrinath, 1997).

Beneish M-score (Beneish): The Beneish M-score assesses how effectively a company manages its earnings. The M-score, akin to the Z-score but with a different aim, evaluates the likelihood of earnings manipulation instead of predicting bankruptcy signs. It comprises eight financial ratios designed to detect either potential earnings manipulation or the resulting distortions in financial statements. An M-score exceeding -2.22 suggests earnings manipulation by the company. Companies with higher Beneish M-scores are more prone to being identified as manipulators (Kukreja et al., 2020). Beneish M-score is calculated by using 8 financial ratios: DSRI (Days' Sales in Receivables Index), GMI (Gross Margin Index), AQI (Asset Quality Index), SGI (Sales Growth Index), DEPI (Depreciation Index), SGAI (Sales General and Administrative Expenses Index), LVGI (Leverage Index), TATA (Total Accruals to Total Assets) (Beneish, 1999). 8 factor M-score is calculated with the following formula:

$$M = -4.84 + 0.92 * DSRI + 0.528 * GMI + 0.404 * AQI + 0.892 * SGI + 0.115 * DEPI - 0.172 * SGAI + 4.679 * TATA - 0.327 * LVGI \quad (3)$$

3.2. Methodology

This study investigates the factors affecting Piotroski F-score. While Piotroski is the dependent variable, Altman, Roic, Inv, PE, MB, EV, Tobin and Beneish are the independent variables in the model. The variables expected to affect Piotroski F-score have been added to the model by considering the relevant literature. Due to the missing values in Beneish M-score variable, unbalanced panel data is used. Following model is used in the analysis:

$$Piotroski_{i,t} = Altman_{\ i,t} + Roic_{\ i,t} + Inv_{i,t} + PE_{i,t} + MB_{it} + EV_{i,t} + Tobin_{i,t} + Beneish_{i,t} \quad (4)$$

Fixed effects panel data analysis is used in this paper. Time invariant heterogeneity and unobserved time varying and time invariant factors can be controlled in the fixed effects specification. To choose between fixed effects and pooled OLS model F test is conducted. As a result of F test, fixed effect specification is preferred to OLS. Secondly, Breusch Pagan Lagrangian Multiplier test is performed to decide between random effects and OLS models. As a result, random effects estimator is chosen. Finally, based on Hausman test, fixed effects estimator is preferred over the random effects estimator. Furthermore, to mitigate the cross-sectional dependency, heteroscedasticity and autocorrelation issues, Driscoll and Kraay (1998) estimator is used. This reliable estimator is opted because it's commonly advised for fixed effect models, especially when the number of entities (N) is greater than the time periods (T) in the panel dataset, which holds true for this study. Driscoll and Kraay (1998) build on large-T asymptotics to show that the standard nonparametric covariance matrix estimator for time-series data can be adjusted to handle both cross-sectional and temporal dependencies. Their method essentially adapts a Newey-West–style correction to the cross-sectional averages of the moment conditions. By modifying the standard error estimates in this way, their approach ensures that the covariance matrix estimator remains consistent, even as the cross-sectional dimension (N) grows indefinitely. This innovation addresses the shortcomings of other large-T–consistent estimators, like the Parks-Kmenta and PCSE methods, which tend to become unreliable when the cross-sectional dimension (N) of a panel dataset is very large (Hoechle, 2007).

4. EMPIRICAL RESULTS

The descriptive statistics of the variables used in this study is shown in Table 1 below. Average firm in the sample has a Piotroski F-score of 5.45. Since Piotroski F-score below 7 indicates weaker financial strength, the financial strength of the sample companies is found out to be weak. The mean value of Altman Z-score is 6.85 (it is above 2.99) and it shows that the sample companies are financially healthy and not at risk of bankruptcy. In terms of earnings manipulation, the sample companies does not show an indication of financial fraud. Since the average Beneish M-score is less than -2.22, the firms have lower tendency to commit fraud. Roic is a tool used to gauge if a company is effectively generating value from the money it puts into its operations. Average Roic value of the firms is 16.71% and this shows that the companies have efficient capital utilization and strong value creation potential.

Furthermore, the manufacturing firms show 108.65% investment growth compared to the previous years. PE and MB ratios of the sample companies are 30.99% and 5.28%, respectively. The generally accepted PE ratio is around 20. Stocks in firms with a PE ratio above 20 are considered expensive, and stocks in firms with a PE ratio below 20 are considered cheap. When a firm's PE ratio is high, the firm's future expectations are high. The limit value for MB rate is considered to be 1. If the MB ratio is greater than 1, this usually indicates that the corresponding firm has profitability or growth potential. A high MB ratio can also reflect investor confidence in a firm. Therefore, these values suggest that investors are willing to pay a higher stock price than the current profit rate because they expect higher profits. The value of the firms is 2.17 times its net sales revenue in average. Finally, average firm has a 2.04 Tobin's Q ratio.

Table 1. Descriptive Statistics

Variable	N	Mean	Sd	p25	p50	p75	min	max
Piotroski	4448	5.45	1.67	4.00	5.00	7.00	1.00	9.00
Altman	4448	6.85	5.24	4.85	6.60	8.91	-41.03	32.75
Roic	4448	16.71	34.40	3.55	11.26	22.94	-99.29	385.36
Inv	4448	108.65	392.21	3.55	19.78	66.71	-95.06	994.37
PE	4448	30.99	242.48	0.00	8.09	17.28	1.13	791.89
MB	4448	5.28	90.06	1.14	1.93	3.65	0.22	226.47
EV	4448	2.17	3.94	0.74	1.18	2.07	0.05	67.70
Tobin	4448	2.04	2.88	1.07	1.37	2.00	0.41	61.70
Beneish	4367	-2.20	25.23	-2.58	-2.04	-1.33	-28.90	90.26

Source: Created by authors with using Finnet Stock Expert (2024).

Pearson correlation coefficients are shown in Table 2. According to the results of Table 2, there is not any multicollinearity issue in the variables. Since the multicollinearity affects the reliability of the regression results, it should be checked firstly. There is not high level of correlation (75%) among the variables. Furthermore, Altman Z-score and Roic positively and significantly affect Piotroski. However, EV variable has a negative impact on Piotroski. While Roic positively affects Altman, Inv and EV negatively affect it. Inv and EV have negative relation with Roic, and Tobin has a positive relation with Roic. There is a positive relation between Tobin and PE. EV also positively affects PE. Finally, Tobin has positive relation with Roic, MB and EV.

Table 2. Pearson Correlation Matrix

	Piotroski	Altman	Roic	Inv	PE	MB	EV	Tobin	Beneish
Piotroski	1								
Altman	0.2035*	1							
Roic	0.2389*	0.2551*	1						
Inv	-0.0502*	-0.1161*	-0.0420*	1					
PE	-0.0117	-0.0031	-0.0183	-0.0082	1				
MB	0.0102	-0.0065	-0.0043	-0.0022	0.0052	1			
EV	-0.0626*	-0.0826*	-0.0603*	0.0531*	0.0776*	0.0334	1		
Tobin	0.0312	0.0206	0.1341*	0.0297	0.0961*	0.0708*	0.6279*	1	
Beneish	-0.0241	-0.0071	-0.0137	0.0189	0.0040	0.0009	0.0169	0.0050	1

Source: Created by authors with using Finnet Stock Expert (2024).

Variance inflation factors (VIF) are also calculated in order to be sure of the absence of multicollinearity problem and it is shown in Table 3. VIF value above 10 is indicative of a serious multicollinearity. VIF value is below 10 for all of the independent variables used in the model. Therefore, there is not any multicollinearity issue among the predictor variables.

Table 3. VIF Values

Variable	VIF	1/VIF
Tobin	2.73	0.365778
EV	2.32	0.430475
Altman	1.53	0.654995
Roic	1.38	0.724877
PE	1.08	0.926806
Inv	1.04	0.958939
MB	1.01	0.991303
Beneish	1.01	0.994168
Mean VIF	1.51	

Source: Created by authors with using Finnet Stock Expert (2024).

In order to test cross sectional dependency, the CD test described in Pesaran (2004) and Pesaran (2015) is used. Cross sectional dependence test results are shown in Table 4.

Table 4. Cross Sectional Dependence Test

Variable	CD-test	p-value	average joint T	mean ρ	mean abs(ρ)
Piotroski	19.602	0	30.78	0.03	0.22
Altman	35.459	0	30.78	0.06	0.38
Roic	98.899	0	30.78	0.18	0.41
Inv	346.497	0	30.78	0.61	0.62
PE	23.831	0	30.78	0.04	0.17
MB	168.776	0	30.78	0.30	0.37
EV	192.644	0	30.78	0.34	0.40
Tobin	195.05	0	30.78	0.35	0.41
Beneish	126.669	0	29.68	0.23	0.30

Source: Created by authors with using Finnet Stock Expert (2024).

Since Pesaran CD test is appropriate when number of cross sections (N) is greater than time dimension (T), it is used in this study. The p-values for all of the regressions are zero. Therefore, the null is rejected which states a cross-sectional independence.

Table 5. CADF Panel Unit Root Test

Variables	I(0) Level
Piotroski	(-6.956)***
Altman	(-4.041)***
Roic	(-7.115)***
Inv	(-18.747)*
PE	(-11.706)***
MB	(-14.951)***
EV	(-1.278)***
Tobin	(-6.757)***
Beneish	(-5.571)***

Source: Created by authors with using Finnet Stock Expert (2024).

Table 5 presents the results of the unit root tests for the variables. To address the issue of cross-sectional dependence in the data, the CADF unit root test developed by Pesaran (2007) is used, as it accounts for this problem. The test results indicate that all variables are stationary at the I(0) level. This outcome leads us to reject the null hypothesis of a unit root, providing confirmation that the series are stationary.

Table 6 shows the autocorrelation and heteroskedasticity test results. Firstly, Durbin-Watson and Baltagi-Wu LBI tests are done in order to test the autocorrelation issue. Since the t statistics of these tests are below 2, there is an autocorrelation issue in the model. Secondly, Modified Wald test is used in order to check heteroskedasticity in the model. The null hypothesis which indicates there is homoscedasticity is rejected. This result suggests that there are varying levels of variability in the errors across different sections, along with some correlations among them. Heteroscedasticity like this can seriously affect the trustworthiness of our regression findings, so it's important to take steps to address it.

Table 6. Heterogeneity, Autocorrelation and Heteroskedasticity Test Results

	Test Statistics	P-Value
Autocorrelation		
Durbin-Watson	0.864	
Baltagi-Wu LBI	0.952	
Heteroskedasticity		
Modified Wald test	617.88	0

Source: Created by authors with using Finnet Stock Expert (2024).

Table 7 shows the results of F test, Hausman test and Breusch Pagan Lagrangian Multiplier test. These tests have been done in order to determine the appropriate model for the analysis. Firstly, the F test is conducted and it is concluded that fixed effects estimator is preferred to pooled OLS method

Secondly, Breusch Pagan LM test have been performed in order to decide between random effects estimator and OLS method. The null hypothesis in the LM test is that variances across entities is equal to zero. Since the null is rejected with a zero p-value, random effects model is preferred to OLS method. Finally, Hausman test have been done in order to make a decision between random effects estimator and fixed effect estimator. Since the null is rejected in the Hausman test, fixed effect estimator is preferred to random effect estimator.

Table 7. Hausman Test and Breusch Pagan Lagrangian Multiplier Test

Test	Test statistics	p-value
F Test	41.09	0
Hausman Test	18.84	0.02
Breusch and Pagan LM test	590.16	0

Since there are autocorrelation, heteroskedasticity and cross-sectional dependence issues in the model, Driscoll and Kraay (1998) standard error estimator is used in order to eliminate these statistical problems. According to the regression results in Table 8, Altman, Roic, MB, Tobin and Beneish variable have impacts on Piotroski F-score. Except Beneish, all the other variables positively affect Piotroski. Altman Z-score positively affects the financial strength of the manufacturing companies. Therefore, firms with lower risk of financial distress supposed to have higher financial health. Furthermore, the coefficient of Roic variable is positive as well. Thus, companies with higher Roic exhibit higher F-score, as better return on invested capital exhibit higher financial health. In addition, a positive relation between MB and Piotroski is reported in Table 8.

Table 8. Regression Results

		Drisc/Kraay		
Piotroski	**Coefficient**	**Std. Err.**	**T statistics**	**P**
Altman	0.060517	0.01052	5.75	0
Roic	0.008254	0.002322	3.55	0.001
Inv	-8.2E-05	6.96E-05	-1.18	0.24
PE	0.000158	0.000152	1.04	0.3
MB	0.0003	0.000112	2.68	0.008
EV	-0.02263	0.015078	-1.5	0.136
Tobin	0.041269	0.023487	1.76	0.081
Beneish	-0.00152	0.00078	-1.95	0.053
_cons	4.861856	0.098384	49.42	0

Source: Created by authors with using Finnet Stock Expert (2024).

Any firm that has an Altman Z-score below 1.8 is said to be financially distressed and toast unless there's a high risk of going bankrupt. Whereas a score of 3 and beyond has the company in the 'safe' zone with a minimal chance of filing for bankruptcy. The average Altman Z-score of the analyzed companies is 6.85, which indicates that these companies are of good financial health in relation to the Piotroski F-score. ROIC relates more with the growth status of the company. This would mean that

businesses which have a higher ROIC. Those which perform their operations more efficiently, will earn a higher income per unit of invested capital and will be in a position to continue investing later on. Since the average ROIC of the companies under analysis is 16.71%, it is expected to have a positive impact on the Piotroski F-score. The MB ratio preferred value is 1. MB ratio equal to 1 implies that the company's equity equals the book value. The average MB value for the companies analyzed is 5.28%. While this figure gives an impression that the shares are over-priced, and so, less attractive investments, they hold true to be preferred investments by investors because they represent financially healthy companies with high Piotroski F-scores. Another independent variable which significantly and positively affects Piotroski is Tobin. A higher Tobin's Q value indicates a higher performance expectation from the company. According to the regression results if the market assigns higher performance expectation to the company, the firm will have higher financial health. This is the excess of the market value of companies over their registered assets for companies that have a Tobin's Q ratio in excess of 1. Since the average Tobin's Q ratio of the companies being analyzed is 2.04, it means that these are companies which can be invested in be added to the investor's portfolios. This is also evidenced by the positive effect of this ratio on the Piotroski F-score. Finally, the regression results report a negative relation between Beneish and Piotroski. A higher Beneish M-score is an indication of greater likelihood of earnings manipulation. A Beneish M-score greater than -2.22 indicates a likelihood of earnings manipulation by the company. Firms with higher Beneish M-scores are more likely to be classified as manipulators (Kukreja et al., 2020). Firms with a high Piotroski F-score tend to have a Beneish M-score close to -2.22. As the Beneish M-score increases, the Piotroski F-score decreases because a higher M-score indicates a greater likelihood of earnings manipulation. This serves as an indication of lower financial health. Therefore, high M-score firms have lower Piotroski F-score thus lower financial health according to Table 8.

5. CONCLUSION

Fama and French (1992) shows that value stocks tend to outperform growth stocks. However, effectively identifying these value stocks and constructing a profitable investment strategy based on them can be challenging and time-consuming. To tackle this challenge, Piotroski developed a model in 2000 that helps identify potentially profitable stocks within the value investing framework. The Piotroski F-score, a key component of this model, serves as a tool for predicting future profitability of companies. Additionally, research by Turtle and Wang (2017) suggests that the F-score can also be used to assess whether the market accurately reflects fundamental information in stock prices. Piotroski F-score is used as a proxy for financial health of a company and financial health of the companies is one of the important factors that affects the investment decisions of the investors. Hence, determination of the financial health of the firms has been an important topic in finance literature. By including profitability, liquidity and operating efficiency variables, this score has been accepted as a favorite metric that determine the strength of a company's financial position. The current study uses Piotroski

F-score as a proxy for financial health and investigates the factors effective on financial health of the Borsa İstanbul manufacturing industry firms. The relevant literature related to Piotroski F-score either examine the impact of firm specific debt structure ratios on the score or investigate the financial performances of the related firms. However, this study fills an important gap in the literature by examining the financial determinants of Piotroski F-score.

According to the fixed effect panel regression with using Driscoll and Kraay (1998) standard error estimators results, the sample firms have higher financial health if they have higher Altman Z-score, higher roic, higher MB, higher Tobin and lower Beneish M-score. Therefore, the analysis results show that firms with higher financial distress will have lower financial health. Furthermore, if the sample firms have better return on invested capital and higher market to book ratios, they will end up with higher financial health as well. While firms with higher performance show higher financial health, the firms with greater likelihood of earnings manipulation have lower financial health. These results highlight the considerations that firms need to take into account to improve their financial health. One of the conclusions drawn is that financial distress should be kept as low as possible to enhance financial health. Additionally, firms should maintain high market value, growth potential, and performance. Lastly, the lower the likelihood of earnings manipulation, the higher the financial health of companies.

The time period, the focus on a single industry, and the consideration of only Borsa İstanbul firms are limitations of this study. The findings obtained will serve to assist investment decisions for both firms and existing and potential investors. Moreover, this study is innovative in that it associates the financial health of firms with the determinants of Piotroski F-score. It is also open to improvement because of the different period considered, the firms studied, the variables involved and the methodology used. For future research, this analysis can be conducted across different industries and countries. A comparison could also be made between the results of Turkish firms and those of foreign firms.

The study does not necessitate Ethics Committee permission.

The study has been crafted in adherence to the principles of research and publication ethics.

The authors declare that there exists no financial conflict of interest involving any institution, organization, or individual(s) associated with the article. Furthermore, there are no conflicts of interest among the authors themselves.

The authors declare that they all equally contributed to all processes of the research.

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