國立政治大學金融學系
碩士論文

基於 F-score 以及修正式 F-score 的交易策略
Trading Strategies based on F-score and Revised F-score

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摘要

　　本研究透過近 20 年來仍屹立不搖的選股模型，Piotroski F-score，建構不同交易策略並進行投資組合比較。此外，本研究以 F-score 為基礎，並利用公司對於每一項指標的達成率給予 F-score 進行分數調整，修改為 Revised F-score。本文以台灣上市櫃公司為研究標的，研究期間從 2013 年 5 月 15 日至 2022 年 3 月 31 日。

　　透過交易策略的設計，我們將逐步調整並增加不同條件，希冀能接近實際交易情況。首先，本文將先討論在固定選取 30 或 50 家公司的投資組合下，比較只考量 F-score 以及同時考量 F-score 以及 Revised F-score 的績效表現。在固定選取 30 家公司並以市值加權的投資組合中，同時考量 F-score 以及 Revised F-score 在統計上顯著優於僅考量 F-score，說明了修改後的評分方式有助於績效的提升。後續在同時考量 F-score 以及 Revised F-score 的模型基礎下，以固定選取 30 家公司並以市值加權的投資組合進行各種條件測試。實證結果顯示，不論在何種策略下，絕對報酬都優於元大台灣 50 ETF 以及台灣加權股價報酬指數。此外，本文最後也考量資金規模並建構投資組合，年化報酬更提升至 36.6%。此方法將提供個人以及機構投資者在此研究的模型中，找出適合的投資標的

關鍵詞: F-score、投資組合、交易策略、台灣股市

Abstract

This research uses the Piotroski F-score, a stock selection model that has been remain strong for nearly 20 years, to construct different trading strategies and compare performance of portfolios. In addition, We use the F-score as the basis and calculate the company's achievement rate for each indicator to adjust the F-score, which is called Revised F-score. This paper considers companies traded in Taiwan Stock Exchange and Taipei Exchange, and the research period is from 15 May 2013 to 31 March 2022.

Through the design of the trading strategies, we will gradually adjust and add different conditions into strategies in order to close to the actual trading situation. First, this research will compare the performance of the F-score with that of the Revised F-score. Under the portfolios with market value weighted and 30 companies in the portfolio, the performance of considering the F-score and the Revised F-score is significantly greater than that of considering the F-score only. The statistical result shows that the revised scoring method can improve the performance significantly. We will conduct further researches on the basis of the portfolio with market value weighted and 30 companies in the portfolio under the consideration of the F-score and the Revised F-score. The empirical results show that, regardless of any strategy, the absolute returns are better than the Yuanta Taiwan Top 50 ETF and TWSE Capitalization Weighted Stock Index-Total Return Index. In addition, this research also considers the size of funds to construct the portfolios and the annualized return can be 36.6% at most. This method provides individual and institutional investors to find suitable investment targets in the model of this research.

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1. INTRODUCTION

For last two decades, F-score, which was proposed by Piotroski (2000), still plays an important role in financial markets as a strong predictor for the future returns and profitability of stocks. Walkshäusl (2020) reviews the researches on F-score and focuses on the relation between F-score and returns. The scope of the research includes Australasia, Far East, Asia-Pacific, Europe, and emerging markets from 2000 to 2018. These researches extensively verify the effectiveness of the F-score from all over the markets.

On the basis of the fundamental information of companies, Piotroski (2000) created and developed a measure to identify stocks within the USA between weak and strong. The results found by the author revealed the significantly positive relation between F-score and the return. It illustrates that there exists a profitable opportunity under the investment strategy of F-score.

Most researches are talking about the topic of return predictability and few of them focus on the implementation of this investment strategy in the real financial market. Krauss et al. (2015) use week and month as trading frequency to see how the F-score strategy performs. Without any frictional and trading costs, the performance does quite well and outperform relevant benchmarks. However, considering the liquidity constraints and the high rebalancing frequencies, the strategy becomes unprofitable and it seems to be unfeasible for either individual or institution investors.

There is little literature focuses on the designing and the development of trading strategies under the F-score and construct portfolios with stocks from the financial market in Taiwan. Chou (2018) revises the F-score and comes up with a new scoring system called C-score. Furthermore, the author simulates the trading strategy and predicts the returns through neural networks to beat the benchmarks. Yeh (2012) tries to improve the performance of portfolios by using the fundamental and the technical methods at the same time. The author not only selects stocks by F-score but also builds the momentum strategy by using past returns, trading value, etc.

Based on the strong predictability and effectiveness of F-score, it is worth doing further researches about how to use this method to design trading strategies which are close to the actual and real transaction situation in the financial markets. Given different market conditions, We will construct the portfolios under the F-score only, and both F-score and Revised F-score simultaneously and compare performance between different

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types of portfolios and the benchmarks.

Section 2 reviews relative literatures more detail. Section 3 presents how this research constructs the F-score and we will also explain the concept of Revised F-score. Section 4 provides the details of the trading strategies. We will construct different kinds of portfolios from simple to complex under the F-score only, and both of the F-score and the Revised F-score. Section 5 explains the sources of data and what variables this research uses to calculate F-score. Also, we will also describe how this research evaluates the performance of portfolios and compare them with benchmarks. Section 6 lists all empirical results of different portfolios. Section 7 concludes our results and findings. We will also discuss the limitation and the further work of this research

2. LITERATURE REVIEW AND MOTIVATION

After the introduction of F-score, there are lots of researches springing up and expanding the scope of relative researches. The markets which are researched and examined expand to multiple countries in Europe (Tikkanen & Äijö, 2018) and (Walkshäusl, 2019), Australia (Hyde, 2014), Asia-Pacific (Ng & Shen, 2020), etc. This research uses the F-score and the Revised F-score to separate the winners and losers like others do, but the differences between our research and the literature above are that the purposes of this research are creating a trading system that can be implemented in the real financial markets and proposing a weighting view for the F-score to adjust the score of each criterion of the F-score.

When it comes to Taiwan, the samples of the literature below are companies traded in Taiwan Stock Exchange or Taipei Exchange. Lin (2021) uses the strategy of Buy and Hold to show how the stock portfolios perform under different sorting criteria which include F-score indicator, Price-to-Earnings ratio, and Dividend-to-Price ratio. The author finds that the combinations of three criteria can improve the performance of investors and beat the benchmark index. Lai et al. (2011) follow the analytical strategy of F-score and also propose a new analytical method called S-score. In addition to the traditional financial ratios, the authors take earning management, earning stability, and ownership structure into consideration. The difference in portfolio returns by the F-score and S-score is negligibly small. However, the S-score has better performances when it adjusts to return risks. Tsai et al. (2017) use a stochastic dominance test to examine the relative performance of stocks under two different sorting criteria which

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are Dividend-to-Price ratio and F-score. The results show that there is a clear stochastic dominance relation of high F-score stocks over low F-score and in spite of the value or growth strategy, the information of F-score can increase the portfolio performance. Wang (2013) examines if an investment strategy that considers both the fundamental and intrinsic value of firms can be better than one which considers the fundamental information alone. The paper also uses R&D/sales ratio for innovation and growth rate of sales for customers as proxies to evaluate the intrinsic value of firms. The "Intrinsic Value Portfolio" formed by the Book-to-Market ratio composite fundamental score R&D/sales ratio and growth rate of sales not only outperforms the "High BM portfolio" and "Fundamental portfolio" but also significantly beats the market and generates the highest Sharpe ratio of all.

This research focuses on the development of trading strategies, and studies if the F-score and the Revised F-score can help investors make their investment decisions better. Considering all frictional costs which include transaction taxes and fees, this research rebalances the portfolios four times in a year in order to avoid a lot of relevant taxes and fees, and the low-frequency strategies reduce the sensitivity of the portfolios to relevant costs. Also, this research proposes multiple solutions for liquidity constraints, and verifies that the trading strategies are still remain available under the strict liquidity requirements. Our goal is that not only the general investors can follow the fundamental information and the rules to select the companies, but also the institutional or investors with large capital can filter out worse investment targets from the large stocks pool through both of the F-score and the Revised F-score.

To our best knowledge, there is little literature considering so many details of transaction and using the percentile of F-score to distinguish good and bad companies instead of the absolute number of it. Furthermore, we provide the concept of the weight to each factor in the F-score and adjust the score of them. Hence, this paper contributes to the literature about a practical trading strategy in the financial markets and a new method to sort companies.

3. RESEARCH METHODOLOGY

There are nine criteria in the F-score and if a company meets one criterion, it gets one point on the scoring board. The more criteria a company meets, the more scores a company gets, and the total scores of a company can be at least zero point or nine points

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at most. These criteria are divided into three categories. The first category is *Profitability*, the second category is *Leverage, Liquidity, and Source of Funds*, and the third category is *Operating Efficiency*.

TABLE 1 shows the criteria which are included in each category of the F-score. These criteria evaluate whether a company operates efficiently with limited assets to acquire stable and growing profit.

TABLE 1: Criteria of Each Category within the F-score

This table shows each criterion in the F-score. Every year, a company is going to be reassessed through every criterion and gets a score at last. The score of each company ranges from 0 to 9.

	Criterion
Panel A: Profitability	
F1	Positive ROA of a company in the current year
F2	Positive cash flow from operations of a company in the current year
F3	The ROA of a company in the current year exceeds that of a company last year
F4	Net income of a company is less than cash flow from operations in the current year
Panel B: Leverage, Liquidity, and Source of Funds	
F5	The ratio of total long-term debt to average total assets of a company in the current year is less than that of a company last year
F6	Current ratio of a company this year exceeds that of a company last year
F7	A company does not issue any new common equities for cash
Panel C: Operating Efficiency	
F8	Gross margin ratio of a company in the current year exceeds that of a company last year
F9	Asset turnover of a company in the current exceeds that of a company last year

The criteria above are viewed as original F-score. Each company has to be examined by every criterion of F-score and finally every company is assigned a score. Under the *Original F-score*, every criterion is as important as others. In the view of this, we come up with a way, which is called *Revised F-score*, to show the importance of each criterion.

The idea of the *Revised F-score* is that we calculate the achievement rate of each

criterion in every quarter at first. Achievement rate means that how many companies of total companies meet the requirement under each criterion. Take the positive ROA of a company in the current year as an example, if total companies are one thousand and only five hundred of them meet this criterion, the achievement rate would be 0.5. After that, in order to highlight the importance of this factor and show how hard to be achieved, whose ROA is positive gets 2 points, in the other words, the reciprocal of the achievement rate. A company still gets zero if it fails to have positive ROA in the current year.

This concept adjusts the score of each criterion in order to emphasize the difficulty of it. We calculate the revised score of each criterion and add them up as Revised F-score. Now, we construct another scoring system to select the companies from the wild range of stock pool and we focus on the comparison between these two scoring systems to see if the performance of portfolios constructed by the F-score and the Revised F-score outperform that of portfolios constructed only by the F-score.

4. DESIGN OF TRADING STRATEGY

Once we have two scoring systems toward companies, some thresholds need to be set up in order to filter out companies with low scores at the first step. Next, we design trading strategies which can be used practically and consider the liquidity of stocks less strictly at first. After the initial analysis, we take the stock liquidity of a company into consideration more strictly to make the trading strategies more feasible.

4.1 Timing of Stocks Selection and Rebalance

Under the original research, the frequency of financial data is on the basis of a year so that the portfolios are rebalanced only once every year. Since we acquire the timely financial data of companies more frequently than before, we form the portfolios quarterly to select the companies according to the financial performance of them during the current quarter and compare the financial data of current quarter with last quarter if necessary. Under the frequency of quarters, we replace companies within the portfolio opportunely to reflect changes in companies' fundamental information.

According to the IFRSs, companies which are traded in Taiwan Stock Exchange have to prepare and announce the consolidated financial statements since 2013. Also, there exist deadlines for financial statements of each quarter so that we can collect

financial data of each company at the specific time within a year. The deadline of each quarter in a year are March 31, May 15, August 14, and November 14 respectively. As long as the time approaches each deadline, we will renew the data and calculate the F-score and the Revised F-score of each company for the further steps.

After filtering out companies of lower scores, we can replace the companies in former portfolio with the new list of companies to form the new portfolio for the next quarter. The replacement will be implemented on the next trading date of each deadline to achieve the market timing. For instance, we have to obtain all the financial information we need before March 31. If the next trading date of March 31 is April 1, then we will sell all stocks in the portfolio of last quarter and buy all stocks chosen for next quarter on April 1 to rebalance the portfolio. During the holding period, we will not change the companies in the portfolio until the next trading date. In the other words, we will hold all the stocks from April 1 to May 16 if the next trading date of May 15 is May 16.

4.2 With Liquidity Constraints

Liquidity is a tough issue to be solved while we are constructing new portfolios for every quarter. To make the trading strategy more useful and practical in the real trading situation, we must set up some standards to break the constrains of liquidity and buy all the companies selected by the F-score and the Revised F-score as possible as we can under the allocation of funds. This research provides two kinds of solution to solve the issue.

First, we use the average trading volume for last three days of each company as a parameter to construct different portfolios. The reason why we use how many lots of 1000 shares of a company as the conditions to filter out companies with poor liquidity instead of turnover of it is that the turnover of each company is so sensitive to a little change of it. This research will use 250, 500, 750, and 1000 lots of 1000 shares of a company as different thresholds to see how the portfolios perform.

Second, if we want to extend the strategy to a wider range of use by various of investors, we must take fund size into consideration. Although the first method above can remove companies with low liquidity from the pool of every quarter, but we still cannot make sure that we can buy all the companies chosen by two scoring systems under large fund size. Given that situation, we are going to calculate the cumulative sum of the average trading value for last three days before the deadline to decide the

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fund size and allocate the fund into each company so that we can trade all the companies for sure under the certain fund size.

4.3 Substitute of Companies in Financial and Insurance Industry

As mentioned before, all of the companies traded in the Taiwan Stock Exchange have to follow IFRSs to prepare for financial statements before deadline of each quarter. Most industries have the same deadline for each quarter except the financial and insurance industry. For the financial and insurance industry, the deadline of first, second, and third quarter delay by half a month at most in comparison with other industries.

Companies in financial and insurance industry still accounts for a certain proportion in the TWSE Capitalization Weighted Stock Index, so that we cannot ignore them. In order to achieve market timing and add the companies in the financial and insurance industry into the portfolios, this research use Futures Contracts of Finance and Insurance Index as an alternative to be part of the portfolios. We can adjust the proportion of the futures contracts and the portfolios to see whether the performance will be improved or not and make the whole trading strategy more flexible and complete.

5. DATA

All data and information are gathered from different modules in the database of Taiwan Economic Journal (TEJ). The sample period starts from 15 May 2013 to 31 March 2022 and the stock pool will be all the companies traded in Taiwan Stock Exchange and Taipei Exchange (Over-the-counter).

5.1 Calculate F-score and Revised F-score

First and the most important step is to access all companies' fundamental data of current and last quarter at the deadline of current quarter and use the accounting accounts in TEJ to match every criterion of the F-score. Under *Profitability*, ROA-Comprehensive Income, which is total comprehensive income of current quarter divided by the average total assets of current and previous quarter, will be used to evaluate whether the ROA is positive or not and whether the ROA improves or not. The cash flow from operations is evaluated whether it is positive or not. The total consolidated income is a variable to represent net income and is compared with the cash flow from operations.

Under *Leverage, Liquidity, and Source of Funds*, this research uses three variables

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which are non-current liability, current ratio, and share capital, to calculate the F-score and the Revised F-score. The non-current liability is the liability that will be repaid beyond one year and it is used to see whether the liability structure of a company gets better or not. The current ratio, which is current assets divided by current liabilities, is used to see if the short-term liquidity of a company makes progress. The share capital is used to see part of change of a company's equity.

Under *Operating Efficiency,* gross margin ratio and total assets turnover are variables to evaluate the operating performance of a company. The gross margin ratio is calculated by the gross margin divided by the net sales revenue. It is used to check whether a company operates better or not. The total assets turnover is calculated by sales revenue divided by the average total assets. It evaluates how a company uses its assets and if a company puts the resource into the right place.

5.2 Evaluate the Performance

After constructing the portfolios based on the scoring systems, we need to evaluate the performance of every portfolio and compare them with the benchmarks. This step also plays a crucial part in the strategy because we have to verify the effectiveness of the trading strategy that we design. This research collects the adjusted open price data of all companies traded in TWSE and OTC to calculate some KPIs to evaluate how portfolios perform. This research uses annualized return, annualized volatility, maximum drawdown, annualized Sharpe ratio, and equity as KPIs to evaluate the portfolios.

TABLE 2 shows the formula of each evaluating factor. The equity is the absolute return which means how much the portfolio grows from one unit capital invested under the profit reinvestment. The annualized return of the portfolio is the return for a year averagely during the investment periods and is calculated by equity to the power of the reciprocal of years and minus one at last. The annualized volatility of the portfolio shows how the portfolios fluctuate for a year averagely and is calculated by the standard deviation of the daily return of the portfolio and multiply by the square root of 252. The Sharpe ratio of the portfolio represents how much return for taking one unit of risk and is calculated by the annualized return divided by the annualized volatility. The maximum drawdown of the portfolio means the maximum potential loss of the strategy and is calculated by the daily equity of the portfolio divided by cumulatively the largest daily equity of the portfolio and then minus one. We choose the minimum value of the

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series as the maximum drawdown.

The unit of annualized return, annualized volatility, and maximum drawdown are percentage and the unit of equity is one hundred percent.

TABLE 2: Description of Performance Evaluation

This table shows the formula of each performance evaluation factor. The time period of the calculation starts from 16 May 2013 to 1 April 2022.

Performance Evaluations	
Annualized Return (%)	$(Equity)^{\frac{1}{Years}} - 1$
Annualized Volatility (%)	$\sqrt{252} * \sqrt{\frac{1}{n-1}\sum_{2}^{n}(r_i - \bar{r})}$
Maximum Drawdown (%)	$Min\left[\left(\frac{Equity}{Cumulative\ Max\ of\ Equity}\right)\right] - 1$
Sharpe Ratio	$\dfrac{(Equity)^{\frac{1}{Years}} - 1}{\sqrt{252} * \sqrt{\frac{1}{n-1}\sum_{2}^{n}(r_i - \bar{r})}}$
Equity (100%)	$(1 + return\ of\ holding\ period)^{the\ number\ of\ quarters} - 1$

During the calculation, the weight of each company is an important element we have to decide. This research provides various of weighting methods and calculates the performance of portfolios for further analysis and comparison. There are equally weighted, market value weighted, F-score weighted, Revised F-score weighted, and transaction value weighted.

Last, this study selects Yuanta Taiwan Top 50 ETF and TWSE Capitalization Weighted Stock Index-Total Return Index for the portfolios we construct to compete with. The former contains the top 50 market value of companies traded in TWSE and the latter is TAIEX with reinvestment. This study adopts the buy and hold strategy for both benchmarks and the holding period of them starts from 16 May 2013 to 1 April 2022.

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6. EMPIRICAL RESULTS

After calculating the F-score and the Revised F-score of each company, we will rank the companies by the scores from high to low. Instead of choosing a fixed score of F-score, this research decides to choose the percentile rank value of it. FIGURE 1 shows the cumulative quantity of companies for each score under the F-score from 15 May 2013 to 31March 2022. Most companies concentrate in the middle of the score and few of them fall on either high or low scores, so it is reasonable to select companies by using the percentile rank value as thresholds.
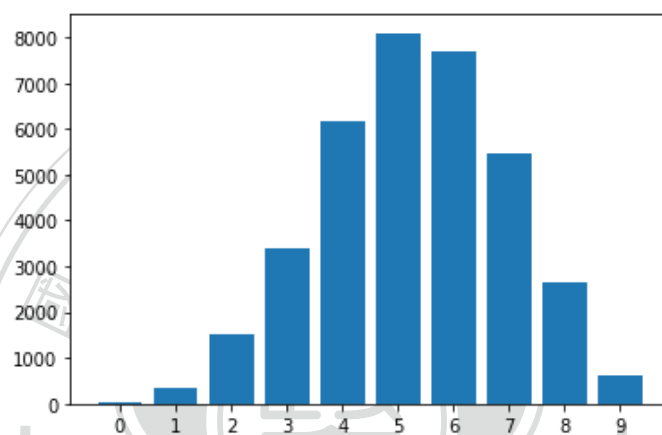

FIGURE 1: Cumulative Quantity of Companies

This figure shows the cumulative quantity of companies under each F-score interval. The time period starts from 15 May 2013 to 31 March 2022. The X-axis represents the F-score which ranges from 0 to 9. The Y-axis represents the cumulative quantity of companies.

This research will take both the F-score and the Revised F-score into consideration to select the companies and form the portfolios for every quarter. We will focus on the comparison of the performance between the portfolios only constructed by the F-score and the portfolios simultaneously constructed by the F-score and the Revised F-score. Our goal is to improve the performance of the portfolios by using the new scoring system which we come up with.

In order to increase the comparability with benchmarks, we select the companies with fixed quantities. This research uses the F-score, the Revised F-score, and the average trading volume for the last three days before the deadline of each quarter to rank the companies from high to low and selects top 30 or 50 companies to form the portfolios. For example, if we want to form the portfolios with 30 or 50 companies under the consideration of only F-score, we will sort the F-score and the average trading

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volume of each company from high to low. On the other hands, we will sort the F-score, the Revised F-score, and average trading volume from high to low and form the portfolios under the consideration of both scoring systems.

The results and the performance of portfolios constructed under different conditions are showed below. First, this research shows how the portfolios with 30 or 50 companies perform under the F-score only and under both of the F-score and the Revised F-score. Besides, we will perform Wilcoxon Signed Rank Test to see whether the holding period returns of consideration of the F-score and the Revised F-score are significantly greater than that of consideration of the F-score or not. Second, the futures contracts of financial and insurance index will be added into the portfolios in order to consider the whole industries within the TWSE and OTC. Third, we will discuss further about the portfolios constructed by different combinations of liquidity and market value.

6.1 Performance of Portfolios with Fixed Quantity of Companies

6.1.1 Considering the F-score only

TABLE 3 shows the performance of portfolios with fixed quantity under the consideration of the F-score. We use PR97 of F-score (EW)(30) to be the portfolio which is constructed by companies whose F-score are greater than the 97th quantile of F-score overall with the weighting method of equally weighted. After filtering out companies with low scores, we will rank the rest of companies by the F-score and the average trading volume for last three days before the deadline of financial statements from high to low and select the top 30 companies at last. The definitions of other portfolios follow the rule above but with different weighting methods and numbers of companies.

Equity of all portfolios are greater than that of benchmarks but Sharpe ratio of portfolio with 30 companies under the market value weighted is worse than benchmarks. Regardless of 30 or 50 companies we select, we find that there is very little to choose between portfolios with equally weighted and F-score weighted and both outperformed portfolio with market value weighted on Sharpe ratio and equity.

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TABLE 3: Performance under Different Percentile Rank Values and Weighting Methods-Considering the F-score only

This table presents the performance of benchmarks and the portfolios with different combinations of percentile rank values, weighting methods, and quantity of companies. PR 97 of F-score means the portfolio constructed by the companies whose F-score are greater than the 97th quantile of F-score overall and PR 95 of F-score means the portfolio constructed by the companies whose F-score are greater than the 95th quantile of F-score overall. EW, MVW, and FSW mean the weighting method of the equally weighted, the market value weighted, and the F-score weighted respectively. 30 and 50 mean 30 or 50 companies in the portfolio. The evaluation period starts from 16 May 2013 to 1 April 2022.

	0050 ETF	TAIEX-Total Return Index	PR97 of F-score (EW) (30)	PR97 of F-score (MVW) (30)	PR97 of F-score (FSW) (30)	PR95 of F-score (EW) (50)	PR95 of F-score (MVW) (50)	PR95 of F-score (FSW) (50)
Annualized Return	0.13953	0.13159	0.26309	0.17807	0.26236	0.26755	0.20107	0.26577
Annualized Volatility	0.15258	0.14559	0.19483	0.20996	0.19378	0.18929	0.20139	0.18812
Maximum Drawdown	-0.25720	-0.28550	-0.29985	-0.34738	-0.29932	-0.30830	-0.31162	-0.30739
Sharpe Ratio	0.91447	0.90384	1.35035	0.84812	1.35386	1.41343	0.99540	1.41271
Equity	3.09055	2.90946	7.52097	4.11943	7.48347	7.75376	4.86841	7.65980

6.1.2 Considering the F-score and the Revised F-score simultaneously

TABLE 4 shows the performance of portfolios with fixed quantity under the consideration of the F-score and the Revised F-score. We use PR94 of F and Revised F-score (EW)(30) to be the portfolio which is constructed by companies whose F-score and Revised F-score are greater than the 94th quantile of F-score and Revised F-score at the same time with the weighting method of equally weighted. After filtering out companies with low scores, we will rank the rest of companies by the F-score, the Revised F-score, and the average trading volume for last three days before the deadline of financial statements from high to low and select the top 30 companies. The definitions of other portfolios follow the rule above with different weighting method and numbers of companies.

The performance of all portfolios with selecting fixed quantity of companies are better than both benchmarks on equities and Sharpe ratio under every weighting method. Regardless of 30 or 50 companies we select, we find that there is very little to choose between portfolios with equally weighted, F-score weighted, and Revised F-score weighted. Despite that the portfolios with equally weighted, F-score weighted, and Revised F-score weighted are outperformed by portfolios with market value weighted on equity, the Sharpe ratio of them are better than that of portfolio with market value weighted.

TABLE 4: Performance under Different Percentile Rank Values and Weighting Methods-Considering the F-score and the Revised F-score

This table presents the performance of benchmarks and the portfolios with different combinations of percentile rank values, weighting methods, and quantity of companies. PR 94 of both F and Revised F-score means the portfolio constructed by the companies whose F-score and Revised F-score are greater than the 94th quantile of F-score and Revised F-score overall and PR 92 of both F and Revised F-score means the portfolio constructed by the companies whose F-score and Revised F-score are greater than the 92th quantile of F-score and Revised F-score overall. EW, MVW, FSW, and RFSW mean the weighting method of the equally weighted, the market value weighted, the F-score weighted, and the Revised F-score weighted respectively. 30 and 50 mean 30 or 50 companies in the portfolio. The evaluation period starts from 16 May 2013 to 1 April 2022.

	0050 ETF	TAIEX-Total Return Index	PR94 of both F and Revised F-score (EW)(30)	PR94 of both F and Revised F-score (MVW)(30)	PR94 of both F and Revised F-score (FSW)(30)	PR94 of both F and Revised F-score (RFSW)(30)	PR92 of both F and Revised F-score (EW)(50)	PR92 of both F and Revised F-score (MVW)(50)	PR92 of both F and Revised F-score (FSW)(50)	PR92 of both F and Revised F-score (RFSW)(50)
Annualized Return	0.13953	0.13159	0.25671	0.28836	0.25584	0.25523	0.22547	0.24367	0.22595	0.22755
Annualized Volatility	0.15258	0.14559	0.18421	0.24498	0.18365	0.18358	0.17419	0.22531	0.17378	0.17395
Maximum Drawdown	-0.25720	-0.28550	-0.30009	-0.40838	-0.29954	-0.29975	-0.30661	-0.39523	-0.30583	-0.30598
Sharpe Ratio	0.91447	0.90384	1.39361	1.17707	1.39305	1.39026	1.29438	1.08149	1.30021	1.30812
Equity	3.09055	2.90946	7.19923	8.92460	7.15607	7.12614	5.79197	6.57884	5.81181	5.87770

6.1.3 Statistical Tests for the Holding Period Returns

After constructing various of portfolios above, we will perform some statistical tests to see if the holding period returns significantly improve under the consideration of the F-score and the Revised F-score at the same time in comparison with the holding period returns under the consideration of the F-score only. As mentioned before, this research uses Yuanta Taiwan Top 50 ETF and TWSE Capitalization Weighted Stock Index-Total Return Index as benchmarks. For the top 50 market value of companies in Yuanta Taiwan Top 50 ETF, the weight of each company is decided by the weighting method of market value weighted. In order to compete with the benchmarks, especially the Yuanta Taiwan Top 50 ETF, this research will focus on the portfolios with market value weighted and conduct further researches.

First, we have to calculate the differences between the holding period returns under the F-score and the Revised F-score and the holding period returns under the F-score only for every quarter. Before we perform the statistical test to see if the difference for every quarter is significantly positive, we have to test whether the distribution of the differences of the returns follows the normal distribution or not. Under the weighting method of market value weighted and 30 companies in the portfolio, FIGURE 2 shows the distribution of difference of the holding period returns between considering both the F-score and the Revised F-score and considering the F-score only. The difference for each quarter is calculated by the returns of considering both scoring systems minus that of considering the F-score only. On the other hand, under the weighting method of market value weighted and 50 companies in the portfolio, FIGURE 3 shows the distribution of difference of the holding period returns between considering both the F-score and the Revised F-score and considering the F-score only. The difference for each quarter is also calculated by the returns of considering both scoring systems minus that of considering the F-score only
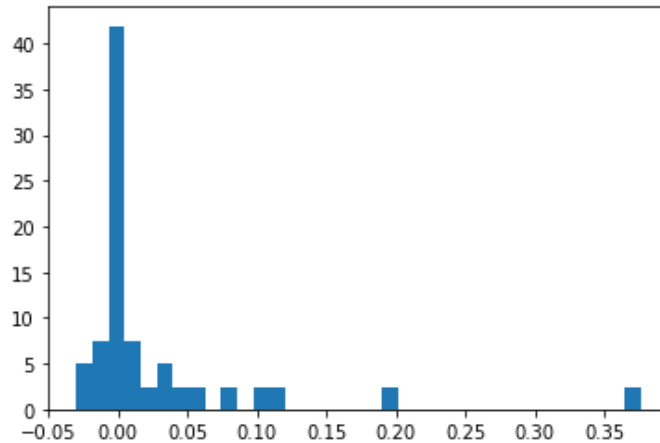
FIGURE 2: The Distribution of Difference of the Holding Period Returns with Market

Value Weighted and 30 Companies in the Portfolio

This figure shows that given the weighting method of market value weighted and 30 companies in the portfolio, the distribution of differences of the holding period returns between considering the F-score and the Revised F-score at same time and considering the F-score only. The X-axis represents differences of the holding period returns and the Y-axis represents the frequency.

FIGURE 3: The Distribution of Difference of the Holding Period Returns with Market

Value Weighted and 50 Companies in the Portfolio

This figure shows that given the weighting method of market value weighted and 50 companies in the portfolio, the distribution of differences of the holding period returns between considering the F-score and the Revised F-score at same time and considering the F-score only. The X-axis represents differences of the holding period returns and the Y-axis represents the frequency.
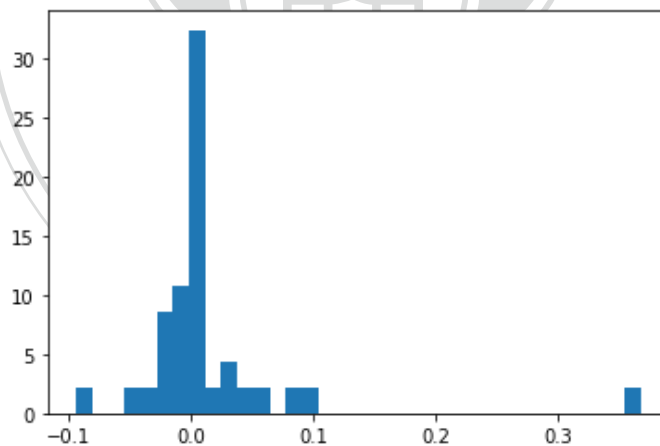
We will perform the Shapiro-Wilk Test to see if the distribution of the return difference under the market value weighted and 30 companies follows the normal distribution for the next step. Also, we will perform the same statistical test to see whether the distribution of the return difference under the market value weighted and 50 companies follows the normal distribution or not. The p-values of the tests for 30 and 50 companies are 6.570484156753764e-09 and 4.3598080701201525e-09 respectively. The results show that both distributions reject the null hypothesis that the return differences follow the normal distribution under the 5% significant level. Based on the statistical results, we cannot perform the Paired T-Test to see if the return differences are significantly positive. Instead, we have to use non-parametric test as an alternative to test the return differences.

Now we will perform the Wilcoxon Signed-Rank Test to see if the return differences are significantly positive for 30 and 50 companies in the portfolios. Under the market value weighted and 30 companies in the portfolio, the p-value is 0.01981. The result rejects the null hypothesis that the return difference is below 0 under the 5% significant level. In contrast, under the market value weighted and 50 companies in the portfolio, the result does not reject the null hypothesis that the return difference is below 0 under the 5% significant level due to the p-value is 0.307001.

Through the necessary statistical tests, we find that the performance improves significantly under the market value weighted and 30 companies in the portfolio after considering the F-score and the Revised F-score at the same time. Under the weighting method of the market value weighted and 30 companies selected, this research will use the portfolio which is constructed by both of the F-score and the Revised F-score to conduct further researches.

6.2 Alternative for the Companies in the Financial and Insurance Industry

As mentioned before, the deadlines for financial statements are different between financial and insurance industry and other industries. In order to achieve the market timing, companies which are used to construct various of portfolios until now are selected from all industries except for the financial and insurance industry. We do not want to select the companies after the announcement of financial statements of financial and insurance industry because the deadlines for financial statements of financial and insurance industry are about two weeks behind that of other industries. Even though we wait for the companies which belong to financial and insurance industry announce their financial statements, these companies may not be as good as being selected into the portfolio.

To solve this problem, this research decides to add the futures contracts of financial and insurance index into the portfolio as alternative. TABLE 5 shows the performance of the futures contracts of financial and insurance index and TF represents the trading code of it. The holding period starts from 16 May 2013 to 1 April 2022.

TABLE 5: Performance of the Futures Contracts of Financial and Insurance Index

This table shows the performance of the futures contracts of financial and insurance index and TF means the trading code of it. The period of evaluation starts from 16 May 2013 to 1 April 2022.

	Annual Return	Annual Volatility	Maximum Drawdown	Sharpe Ratio	Equity
TF	0.12010	0.15143	-0.31566	0.79309	2.66396

Under the consideration of the F-score and the Revised F-score, we continue to use the portfolio with the market value weighted and 30 companies as the basis. We will add the futures contracts of financial and insurance index into the portfolio. The

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weight of TF ranges from 0% to 15% because the data shows that the companies within the financial and insurance industry account for around 10% in the 0050 ETF. Overall, it is reasonable to set the range of the weight for TF.

TABLE 6 shows the results of adding the TF into the portfolio can improve the performance by increasing the Sharpe ratio. Overall, we can construct better portfolios than benchmarks by considering all industries despite that there is a trade-off between increasing the Sharpe ratio and decreasing the annualized return and equity.

TABLE 6: Performance of Portfolios with Different Weights between TF and Portfolios Selected by F and Revised F-score with Market Value

Weighted and 30 Companies in the portfolio

This table shows the performance of benchmarks and the portfolios with market value weighted and 30 companies in the portfolio. PR 94 of both F and Revised F-score means the portfolio constructed by the companies whose F-score and Revised F-score are greater than the 94th quantile of F-score and Revised F-score overall. 30 means that there are 30 companies in the portfolio. TF means the futures contracts of financial and insurance index and the number of the percentage means the weight of it. The evaluation period starts from 16 May 2013 to 1 April 2022.

	0050 ETF	TAIEX-Total Return Index	PR94 of both F and Revised F-score (30) with TF 0%	PR94 of both F and Revised F-score (30) with TF 5.0%	PR94 of both F and Revised F-score (30) with TF 10.0%	PR94 of both F and Revised F-score (30) with TF 15.0%
Annualized Return	0.13953	0.13159	0.28836	0.28304	0.27755	0.27188
Annualized Volatility	0.15258	0.14559	0.24498	0.23623	0.22763	0.21925
Maximum Drawdown	-0.25720	-0.28550	-0.40838	-0.40448	-0.40022	-0.39555
Sharpe Ratio	0.91447	0.90384	1.17707	1.19816	1.21933	1.24003
Equity	3.09055	2.90946	8.92460	8.61156	8.29853	7.98550

6.3 Comparing the Performance of Portfolios under Different Combinations of Liquidity and Market Value

Even though this study ranks the companies by using the F-score, the Revised F-score, and average trading volume for last three days of each company from high to low in the previous research, we still need to consider the liquidity more strictly. Now we are going to set several conditions of liquidity which are from lenient to strict. Also, we differentiate the portfolios between large-cap and small-cap companies for each specific liquidity to see what kind of portfolios perform better.

First, this research uses the average trading volume for last three days and sets different thresholds to filter out companies with low liquidity. Second, in order to distinguish companies with large-cap from that with small-cap, we use the 50th quantile of market value as the boundary to construct portfolios with different market sizes. The stock pool for selecting the large-cap companies is that the market values of companies are greater than the 50th quantile of market value. However, the stock pool for selecting the small-cap companies is that the market values of companies are less than the 50th quantile of market value.

For the portfolios with large-cap, we rank the companies by the F-score, the Revised F-score, and the market value from high to low and selected the top 30 companies. In contrast, for the portfolios with small-cap, we rank the companies by the F-score, and the Revised F-score from high to low but the market value of them is from low to high. We also select the top 30 companies to from the portfolios.

TABLE 7 shows the results of consideration of liquidity and market value. We can conclude two points by conducting this strategy. First, as the requirements of liquidity became harder, the equities of both large-cap and small-cap do not decrease so much and still outperform both benchmarks. Second, no matter how strict the liquidity is, the portfolios constructed by companies with small-cap outperform the portfolios

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constructed by companies with large-cap under every liquidity.

TABLE 7: Performance of Portfolios Selected by F and Revised F-score with Market

Value Weighted and 30 Companies in the portfolio under Different Trading Volume

This table shows the performance of benchmarks and the portfolios with market value weighted and 30 companies in the portfolio. The thresholds of the average trading volume for last three days before the deadline of each quarter are 250, 500, 750, and 1000. Large-cap means that the portfolio is constructed by the companies whose market value are greater than the median of market value of all companies and the average trading volume is higher than each threshold. Small-cap means that the portfolio is constructed by the companies whose market value are less than the median of market value of all companies and the average trading volume is higher than each threshold. The evaluation period starts from 16 May 2013 to 1 April 2022.

	Annualized Return	Annualized Volatility	Maximum Drawdown	Sharpe Ratio	Equity
0050 ETF	0.13953	0.15258	-0.25728	0.91447	3.09055
TAIEX-Total Return Index	0.13159	0.14559	-0.28553	0.90384	2.90946
Panel A: Above 250 lots of 1000 shares					
Large-cap	0.21024	0.19361	-0.30987	1.08588	5.19895
Small-cap	0.28245	0.22330	-0.35386	1.26486	8.57705
Panel B: Above 500 lots of 1000 shares					
Large-cap	0.19625	0.19237	-0.31040	1.02018	4.70220
Small-cap	0.27884	0.23298	-0.37779	1.19684	8.37093
Panel C: Above 750 lots of 1000 shares					
Large-cap	0.16903	0.19190	-0.34005	0.88081	3.85418
Small-cap	0.26426	0.23858	-0.35257	1.10766	7.58168
Panel D: Above 1000 lots of 1000 shares					
Large-cap	0.16587	0.19556	-0.33426	0.84817	3.76519
Small-cap	0.29392	0.24298	-0.36939	1.20963	9.26295

6.4 Constructing the Portfolios on Different Fund Size

Although we consider so many conditions and construct different portfolios, there are still some problems needed to be solved. Liquidity of stocks is one of the most serious challenge this research encounter. We find that even we take the average trading volume for last three days of each company into consideration, it is still difficult for us to buy the required position which we calculate under the weighting method of market value weighted.

In order to solve this problem, this research comes up with a solution to overcome the restriction of liquidity and buys the required position of each company at the same time. Now, we still consider the F-score and the Revised F-score of each company simultaneously. In addition to considering both scoring systems at once, this research will also continue the previous result to form the portfolios with small-cap and set the quantity of the portfolios to be 30.

First, we have to decide the fund size which we want to invest into the portfolios. To form the portfolios with small-cap, this research sorts the companies by the F-score, the Revised F-score, and the market value. The first two are from high to low while the market value is from low to high. Last, we select top 30 companies to construct the portfolio.

After constructing portfolios for every quarter, we calculate the sum of the average trading value for last three days before the deadline of financial statements. TABLE 8 shows the maximum, minimum, and average trading value of the portfolios according to the historical data. In order to buy every company and make this strategy practical, this research decides to use the minimum trading value as the fund size conservatively. Under the conservative situation, the fund size of the portfolios with small-cap could be around 0.4 billion New Taiwan Dollar.

TABLE 8: Cumulative Sum of the Average Trading Value of Companies in Small-Cap

This table shows cumulative sum of the average trading value of the companies with small-cap according to the historical data. The unit of the fund size is one thousand New Taiwan Dollar. The maximum value is about 56 billion, the average value is about 6 billion, and the minimum value is about 0.4 billion. This study uses the minimum value as the fund size to do the further research. The calculation period starts from 15 May 2013 to 31 March 2022.

	Fund Size
Max	56266985.0
Min	476186.0
Average	6058920.0

TABLE 9 shows the results of different portfolios. The weight of each company is the average trading value for last three days divided by the sum of the average trading value for last three days of all companies selected. Obviously, the results were similar to those we find before. All portfolios outperform the benchmarks on Sharpe ratio and equity and there is a trade-off between Sharpe ratio and equity after adding the TF into the portfolios with increasing weights of it.

Although the portfolios still perform quite well, we notice that there is a rise in the annualized volatility and the maximum drawdown of portfolios. Under the only weighting method of the transaction value weighted, the weights may concentrate more on few companies so that the portfolios become more volatile than others.
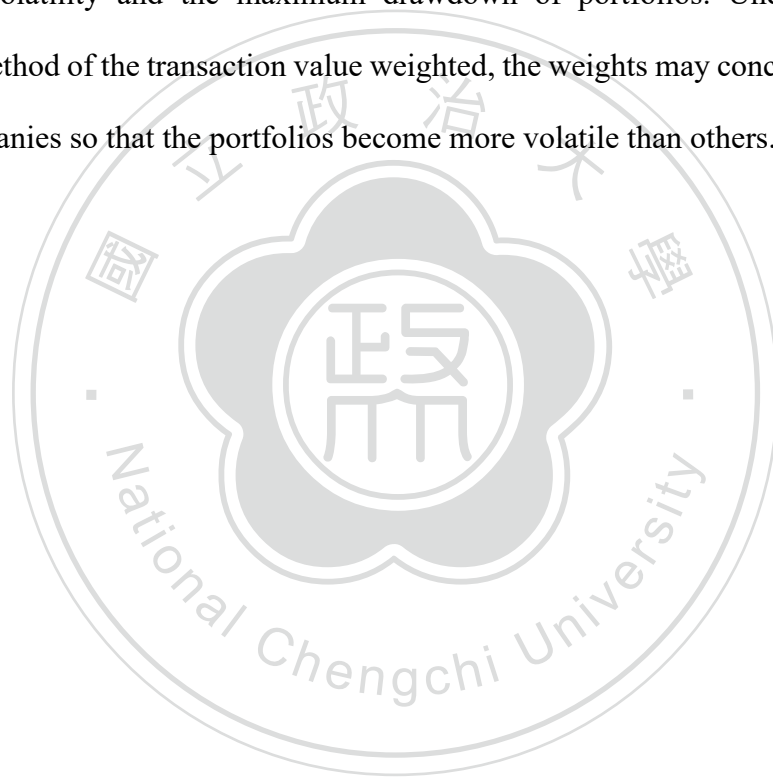
TABLE 9: Performance of Portfolios with Different Weights between TF and Portfolios Selected by F and Revised F-score with Transaction

Value Weighted and 30 Companies in the portfolio

This table shows the performance of the benchmarks and that of the portfolios constructed by the F-score and the Revised F-score with transaction value weighted and 30 companies in the portfolio. Besides, the portfolios are constructed by the companies with small-cap and there are different combinations of weights between the portfolio and the TF. The evaluation period starts from 16 May 2013 to 1 April 2022.

	0050 ETF	TAIEX-Total Return Index	TF	Small-cap with TF 0%	Small-cap with TF 5%	Small-cap with TF 10%	Small-cap with TF 15%
Annualized Return	0.13953	0.13159	0.12010	0.36669	0.36008	0.35321	0.34606
Annualized Volatility	0.15258	0.14559	0.15143	0.31811	0.30544	0.29293	0.28061
Maximum Drawdown	-0.25728	-0.28553	-0.31566	-0.42421	-0.42142	-0.41835	-0.41497
Sharpe Ratio	0.91447	0.90384	0.79309	1.14571	1.17160	1.1982	1.22537
Equity	3.09055	2.90946	2.66396	14.8607	14.25087	13.64103	13.03119

7. CONCLUSION AND FURTHER WORKS

From the theoretical point of view, this research comes up with a new scoring method, which is the Revised F-score, to adjust the scores of the original F-score. This research also performs the statistical tests to show that under the weighting method of the market value weighted and 30 companies in the portfolio, the performance of the portfolio constructed by the F-score and the Revised F-score significantly improves and outperforms the performance of the portfolio constructed by the F-score alone.

From the feasible point of view, this research adopts a series of methods to modify the trading strategy and makes the whole strategy available as much as possible to close the real market situation. The methods include selecting the specific quantity of companies, adding the futures contracts of financial and insurance industry into the portfolio, considering the liquidity of stocks, and taking the fund size into consideration.

All the portfolios this research constructs outperform the benchmarks on absolute return and most of the portfolios have better Sharpe ratio than the benchmarks. Also, the performance of the portfolios with small-cap outperforms that with large-cap under every liquidity constraint. It illustrates the effect of Small-Minus-Big that investors can acquire more returns by investing companies with lower market value. Last, under the consideration of the liquidity and the fund size together, we construct the portfolio with the highest Sharpe ratio and equity.

There are still lots of issues for further studies. First, we can observe that even though most portfolios outperform the benchmarks, the annualized volatility and the maximum drawdown remain over 20 percent. Stop-Loss and Stop-Profit may reduce the overall volatility of the portfolios after we take both of them into consideration. Second, we can adopt the Long-Short strategy through buying the companies within the top n percent of overall F-score or Revised F-score meanwhile selling short the companies within the last n percent of overall F-score or Revised F-score under the

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feasible short selling conditions. We may compare the Long-Short strategy with the Long-only strategy to see whether the performance improves or not. Last, there is still a long way to go for the decision of how we allocate the weights to each company. Though the first priority is to select the right companies, but the weights of it will play an important part in the performance evaluation.

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