

YMC Management Review**Volume 14, No.1, 2021 pp. 45-61****Revise the value investing strategy of F-score**

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Abstract

Piotroski (2000) selects samples that with lower book-to-market ratio and higher F-score to form value investing portfolio. This study modifies his procedure by two ways and use Taiwan data from 2001 to 2020 to test the performance. First, we select samples with high and increasing F-score. The annualized return is found to be 26.78% that is about 4.6% higher than the performance of Piotroski (2000). Second, we add addition indicators (P/E, momentum, and firm size) as third indicator, we show an annualized return of 29.16%. Such modification improves the efficiency of value investing. In addition, we suggest one-year evaluation period for samples and one-year holding for value investing. Our selection procedure generates limited candidates based on one-year cycle, benefiting retail investors who have no sufficient capital and suffer from frequent trading.

Keywords: *Value investing, F-score, Book-to-market, P/E, momentum, Firm size*

1. Introduction

Value investing that picking undervalued stocks based on firms' fundamental characteristics that can be obtained from financial statements such as the EPS and book-to-market ratio has been widely applied by investors. These value stocks tend to be neglected and/or the information is less accessed by the market, leading to the market prices deviate from the intrinsic values. Investors can hold them as a long-term investment and be rewarded at the time the true value is uncovered. Therefore, the concept of value investing is to detect the undervalued stock by studying firms' financial performance. Piotroski (2000) find portfolio that is formatted based on the F-score, which is measured by 9 financial indicators, earns higher return. This study tends to find out healthier firms from the undervalued samples first identified by the method of Piotroski (2000) and goes further to filter them by the other indicator. In short, this study tries to find more good and undervalued stocks by a multiple filtering way and examine if such proposed method can create a stronger value portfolio.

Book-to-market ratio (BM) is widely used to identify value stocks. Firms with higher BM are more likely to be undervalued and have higher return in the after (Fama and French, 1992; Lakonishok et al., 1994; Piotroski, 2000). However, Piotroski (2000) documents that less than 44% of all high BM firms earn positive market-adjusted returns in the two years following portfolio formation. That is, not all the high BM stocks are the best candidates in value investing. A further filtering is then expected for having a better identification. This study plans to sort out samples first by the BM and second by the F-score of Piotroski (2000), finally by either P/E ratio, momentum, or firm size as the third selection criteria. A well-constructed process is suggestive especially for retail investors who in general are suffered from frequent trading.

Picking out good value stocks is the core idea in value investing. This study tries to improve the procedure of Piotroski (2000) by two ways. First, his F-score measures how good the firm is by 9 financial indicators. Firms with higher F-score are identified as good firms. Piotroski (2000) selects good and undervalued samples as a value investing portfolio. Here, we add a new criterion of "increasing F-score" to collect samples in progress. Second, we extend the observation period on F-score from one-year to two- or three-years. That modification better captures the dynamic financial performance of target firms.

Using Taiwan data from 2000 to 2020 that covers the event of financial crisis in 2008, this study finds 26.78% annualized rate of return for portfolio that add in increasing F-score criteria. It is 4.6% more than the results using the method of Piotroski (2000). When three additional indicators are applied as third filtering rule (P/E, size, and momentum), the annualized rate of return for portfolios are 27.44%, 29.11%, and 29.16% respectively. This study shows the multiple filtering procedure improving the efficiency of value investing. When taking the observation period and the time span of portfolio holding into consideration, we find the one-year observation period rule and one-year holding make better results.

2. Literature review

Lakonishock, Shleifer and Vishny (1994) argue the value stocks are undervalued due to individual and institutional investors won't invest on value stocks. Individual investors believe the value firms have financial distress because they earn less returns than glamour firms. Meanwhile, fund managers intend not to invest on value stocks because it is hard for them to explain why they long poor performing stocks to their funders. In addition, it takes a long period of time to get expected return for value investing, making fund managers less willing to take that risk. The less attractiveness makes value stocks undervalued. In addition, the value premium of Fama and French (1992) suggests that mispricing contributes to investors don't have sufficient information to evaluate the firms nor overreact to the bad news.

The mispricing can be discovered by the disclosure of financial information such as firms' profitability, dividend payout level, or solvency. This idea consists with the semi-strong form of market efficiency that stock price reflects the open access information. Good financial performance boosts stock price especially to high BM firms that are more likely to be undervalued. Therefore, managers in value firms should make more effort on the accounting information disclosure (Asness, 1997) to eliminate the mispricing. For finding out the potential value stocks, prior researchers try to use single or composited indicators based on financial information. Aras and Yilmaz (2008) find the P/E ratio can be applied to predict future return especially in emerging markets. Fama and French (1995) argue firms with higher BM and smaller size earn higher returns. Chen and Zhang (1998) find the ROA and ROE explain stock price changes. Piotroski (2000) takes 9 financial variables like the ROA, cash flow from operation, and accruals to form aggregate signal measure (F-score) and find the higher F-score firms in higher BM group have higher return. Identifying value stocks by firms' financial characteristics is evidenced to earn better return.

Basu (1977) finds firms with lower P/E ratio have higher returns than those with higher P/E ratio. Higher P/E means investors should pay more for obtaining that assets, whereas a lower P/E implies a relative lower price. Therefore, investors intend to buy lower P/E target and earn higher return if else being equal. Fama and French (1992) show the size effect in stock markets that a portfolio of smaller size firms outperforms a portfolio of bigger size firms. Loughran (1997) argues the size effect is caused partially by that fund managers are less willing to invest on smaller size firms for safety reason. The lower confidence of investors on small size firms leads to the mispricing, making firm size as an indicator of undervaluation. Further, Jegadeesh and Titman (1993) find the prior winners perform better than those prior losers. So called momentum strategy suggests the prior performance is an indicator to future returns. Jegadeesh and Titman (2011) report the momentum strategy works cross markets over time.

As to the concept of picking out value stocks, using one or more criteria is the other concern. For having a better result, applying more criteria improves the quality since there is no absolute indicators that can identify value stocks successfully. La Porta (1996) uses BM, firm size, and earnings to identify samples. He argues investors intend not to buy stocks with lower BM, smaller size, and lower earnings, leading to mispricing. Nartea, Ward, and Djajadikerta (2009) use firm size and BM as indicators to filter out value firms from prior winners. Piotroski (2000) and Tikkanen and Äijö (2018) use the BM and the 9-indicators created F-score to sort out value firms. Applying multiple indicators is suggestive for value investing.

The finding of Piotroski (2000) can also be evidenced outside the US market. Tikkanen and Äijö (2018) show similar result using data from European market in the period of 1992 to 2014. This study plans to use Taiwan data and add value to the method of Piotroski (2000) by applying additional three indicators, the P/E ratio, firm size, and momentum. Moreover, we try to modify the procedure of Piotroski (2000) to improve the quality of filtering. Piotroski (2000) uses BM as the first indicator to sort out lower BM samples as candidates and then applies F-score as the second indicator to pick out value stocks from them. We change the criteria of “high F-score” of Piotroski (2000) by “increasing F-score” in the selection process. In addition, we extend the time period of observation from the one-year of Piotroski (2000) to two- or three-years. Both changes are applied to capture the continued and undervalued samples.

3. Methodology and Research Design

3.1 Variables

This study obtains stock returns and financial data from Taiwan Economic Journal in the period of 2000 to 2021. All public firms in either Taiwan Stock Exchanges or Taipei Stock Exchange are included. We test the performance of created portfolios in the period of 2001 to 2021.

The method of Piotroski (2000) uses BM as the first filter to find out value stocks and F-score as the second filter to select good candidates from those value stocks. We collect and compute the financial data at the end of each fiscal year. The BM is the book value to market value of a firm. The return-on-assets (ROA) is computed as the net income before extraordinary item scaled by the total assets at the end of prior year. Δ ROA is the difference between the current and prior year on ROA. The cash flow from operations (CFO), computed as the cash flow from operations scaled by the total assets at the end of prior year. ACCRUAL is the current year's net income before extraordinary items less cash flow from operations and then scaled by the total assets at the end of prior year. Piotroski (2000) use the ROA, Δ ROA, CFO, ACCRUAL as performance-related measurement of a firm. We also compute the Δ LEVER as the change in the ratio of long-term debt to average total assets between current and prior year. The Δ LIQUID is the change in the current ratio between the current and prior year. The current ratio is

the current assets to current liabilities at the end of the fiscal year. The EQ-OFFER is a dummy variable. It equals to one if the firm does not issue new common stock in the year and zero elsewhere. Piotroski (2000) use the Δ LEVER, Δ LIQUID, and EQ-OFFER to measure the changes in firm's capital structure and the ability to meet future debt service obligations.

Finally, Piotroski (2000) uses two measures, the Δ MARGIN and Δ TURN, to proxy the changes in the efficiency of firm's operation. The firm's current gross margin ratio is computed as the gross margin scaled by its total asset. The Δ MARGIN is defined as the difference between the current gross margins in current and prior year. In addition, the asset turnover ratio is the total sales scaled by the total asset at the end of prior year. Δ TURN is the difference between the asset turnover ratios in current and prior year. We follow Piotroski (2000) to measure the 9 indicators that cover the profitability, solvency, and operating efficiency to composite his F-score.

The F-score sums up the scores of the 9 indicators. The F_ROA (F_ΔROA, F_CFO) equals to one if the ROA (ΔROA, CFO) is positive and zero elsewhere. Also, the F_ΔLEVER (F_ΔLIQUID) equals to one if the ΔLEVER (ΔLIQUID) is positive and zero elsewhere. EQ-OFFER is a dummy variable, F_EQ-OFFER is one if EQ-OFFER is one and zero elsewhere. Finally, the F_ΔMARGIN (F_ΔTURN) equals to one if ΔMARGIN (ΔTURN) is positive and zero elsewhere. The F-score therefore is ranged from 0 to 9. The higher F-score a firm has, the better quality the firm is. We compute the F-score for every firm from 2000 to 2020.

This study applies the P/E, size, and momentum as the third indicator. The P/E is the price-to-earnings ratio computed as the market price to its earnings per share at the end of the fiscal year. Size is market capitalization of the firm, computed as the total number of share outstanding times the share price at the end of the year. The momentum is the price performance of the firm in prior year, computed as the difference between the stock prices at the first and last trading day scaled by the price at the first trading day.

3.2 Research design

More than the method of Piotroski (2000), this study (1) adds new criteria that samples should perform better than before; (2) applies the third indicators (P/E, size, or momentum); and (3) extends the observation period to the F-score evaluation (1-, 2-, or 3-year), in the value stock selection process. The 2-year (3-year) F-score is computed as the average of the two (three) F-scores measured in the observation period. In sum, we have 13 types of portfolio construction. They are reported in Table 1.

3.3 Portfolio performance

We measure the portfolio performance by above 13 ways from 2001 to 2020. The annual financial statements will be disclosure no later than March, 31 by regulations in Taiwan. This study sets up new portfolio on April, 1

Table 1

The research design about the way of constructing value stock portfolio

Type	Selection process	Explanation
A	1. Low BM 2. High F-score	1. Find out 50 samples with lowest BM from the market 2. Find out the highest F-score 10 from the 50 value stocks as a portfolio
B1	1. Low BM 2. High F-score 3. F-score ↑	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their F-score 3. Find out 10 samples with increased F-score form the 50 candidates as a portfolio.
B2	1. Low BM 2. High F-score 3. 2Y-F-score ↑	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 2-year F-score 3. Find out 10 samples with increased 2-year F-score form the 50 candidates as a portfolio.
B3	1. Low BM 2. High F-score 3. 3Y-F-score ↑	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 3-year F-score 3. Find out 10 samples with increased 3-year F-score form the 50 candidates as a portfolio.
C1	1. Low BM 2. High F-score 3. F-score ↑ 4. Low P/E	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their F-score. 3. Find out 10 samples with increased F-score by the order in step 2. 4. Select at most 5 targets with positive but lowest P/E from the 10 samples in step 3 as a portfolio.
C2	1. Low BM 2. High F-score 3. 2Y-F-score ↑ 4. Low P/E	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 2-year F-score. 3. Find out 10 samples with increased 2-year F-score by the order in step 2. 4. Select at most 5 targets with positive but lowest P/E from the 10 samples in step 3 as a portfolio.
C3	1. Low BM 2. High F-score 3. 3Y-F-score ↑ 4. Low P/E	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 3-year F-score. 3. Find out 10 samples with increased 3-year F-score by the order in step 2. 4. Select at most 5 targets with positive but lowest P/E from the 10 samples in step 3 as a portfolio.
D1	1. Low BM 2. High F-score 3. F-score ↑ 4. High moment	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their F-score. 3. Find out 10 samples with increased F-score by the order in step 2. 4. Select at most 5 targets with highest momentum from the 10 samples in step 3 as a portfolio.
D2	1. Low BM 2. High F-score 3. 2Y-F-score ↑ 4. High moment	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 2-year F-score. 3. Find out 10 samples with increased 2-year F-score by the order in step 2. 4. Select at most 5 targets with highest momentum from the 10 samples in step 3 as a portfolio.
D3	1. Low BM 2. High F-score 3. 3Y-F-score ↑ 4. High moment	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 3-year F-score. 3. Find out 10 samples with increased 3-year F-score by the order in step 2. 4. Select at most 5 targets with highest momentum from the 10 samples in step 3 as a portfolio.
E1	1. Low BM 2. High F-score 3. F-score ↑ 4. Small size	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their F-score. 3. Find out 10 samples with increased F-score by the order in step 2. 4. Select at most 5 targets with smallest firm size from the 10 samples in step 3 as a portfolio.
E2	1. Low BM 2. High F-score 3. 2Y-F-score ↑ 4. Small size	1. Find out 50 samples with lowest BM from the market. 2. Sorting 50 candidates based on their 2-year F-score. 3. Find out 10 samples with increased 2-year F-score by the order in step 2. 4. Select at most 5 targets with smallest firm size from the 10 samples in step 3 as a portfolio.

E3	1. Low BM 2. High F-score 3. 3Y-F-score ↑ 4. Small size	1. Find out 50 samples with lowest BM from the market. 2. Sorting candidates based on their 3-year F-score. 3. Find out 10 samples with increased 3-year F-score by the order in step 2. 4. Select at most 5 targets with smallest firm size from the 10 samples in step 3 as a portfolio.
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in every year by the 13 ways and measure the one-year buy-and-hold returns (BHR) as shown in equation (1). The buy-and-hold return is computed as the difference on the value of portfolio at beginning and end divided by the value of portfolio at the end of the observation period. That is, we long value stocks on April, 1 and short them on the March, 31 of the next year. For making comparison, we also compute the annualized rate of return (ARR) in equation (2) for the 13 value investing strategies. The n in equation (2) is the number of years. Moreover, the handling charge (0.1425%) and the transaction tax (0.3%) for each transaction are deducted in the computation.

$$BHR = \frac{\text{value of portfolio at end} - \text{value of portfolio at beginning}}{\text{value of portfolio at beginning}} \quad (1)$$

$$ARR = \sqrt[n]{\frac{\text{value of portfolio at end}}{\text{value of portfolio at beginning}}} - 1 \quad (2)$$

We also take the risk into consideration and compute the Sharpe ratio for the performance of each strategies. The Sharpe ratio is computed as the return of portfolio less the risk free rate divided by the standard deviation of the portfolio. We use the mean value of the interest rate from the five largest banks in Taiwan as the risk free rate.

4. Empirical results

We classify the 13 value investing strategies by 5 categories (A, B, C, D, and E) as reported in Table 1. Type A is the results using Piotroski (2000) and is used for comparison. Type B includes a condition of increase F-score measured on one-, two-, and three-year base. Type C, D, E applies P/E, momentum, and firm size respectively as the third filter. The performance of each strategy are reported in the following.

4.1 A and B strategies

Table 2 reports the performance of type A and B strategies. The AAR for type A is about 22.18%, which is lower than any one of the type B strategies (26.78%, 22.63%, and 22.36%), showing the idea of increasing F-score is suggestive. The F-score represents firm's condition at the time of making value investing decision. The type B strategy weights more on the progress of value firms, arguing undervalued (by BM), good (by F-score) and getting better (by increasing F-score) firms are the candidates.

Among the type B groups, we can see the B1 strategy has highest AAR (26.78%). Such findings suggest the evaluation period needs not to be long. One-year observation is enough. Moreover, the Sharpe ratios for all the

Table 2

Performance of strategy A and B

The table reports the BHR and AAR for strategy A that is conducted following Piotroski (2000) and for strategy B that asks value firms should perform better than before on the base of one-, two-, or three-year observation. The Cum. BHR is the cumulative BHR over the 20 years. The Sharpe ratio and the standard deviation (St. Dev.) of the portfolios are reported. The maximum and minimum BHR for the respective strategy are also presented.

Type	A		B1		B2		B3	
Year	BHR	AAR	BHR	AAR	BHR	AAR	BHR	AAR
2001	13.55%	13.55%	9.76%	9.76%	10.60%	10.60%	14.09%	14.09%
2002	-0.07%	6.52%	36.77%	22.53%	28.79%	19.35%	17.48%	15.77%
2003	142.31%	40.09%	141.55%	53.63%	110.11%	44.11%	152.18%	50.08%
2004	-23.89%	20.27%	-23.09%	29.23%	-32.15%	19.37%	-19.94%	28.26%
2005	-10.07%	13.48%	-10.59%	20.05%	-0.56%	15.09%	-0.32%	21.95%
2006	90.86%	23.75%	84.45%	28.96%	75.03%	23.42%	56.90%	27.18%
2007	1.93%	20.37%	1.34%	24.59%	2.77%	20.23%	10.40%	24.64%
2008	-32.37%	12.00%	-31.70%	15.57%	-35.14%	11.31%	-35.80%	14.72%
2009	170.96%	23.55%	180.19%	27.52%	180.19%	23.33%	148.36%	25.00%
2010	43.67%	25.43%	42.83%	28.98%	40.25%	24.92%	40.15%	26.44%
2011	-13.66%	21.24%	-21.83%	23.24%	-19.73%	20.00%	-6.79%	22.98%
2012	16.60%	20.85%	16.74%	22.68%	17.55%	19.79%	27.58%	23.36%
2013	61.92%	23.60%	87.25%	26.74%	59.64%	22.47%	49.76%	25.21%
2014	26.34%	23.79%	20.80%	26.31%	25.85%	22.71%	12.36%	24.25%
2015	-7.95%	21.37%	-8.47%	23.62%	-6.63%	20.49%	-12.21%	21.40%
2016	50.80%	23.03%	86.57%	26.84%	79.71%	23.54%	81.66%	24.50%
2017	17.18%	22.68%	9.65%	25.76%	6.21%	22.45%	3.22%	23.13%
2018	9.81%	21.93%	9.56%	24.80%	-1.87%	20.95%	-9.15%	21.07%
2019	-16.36%	19.53%	-14.82%	22.32%	-13.75%	18.82%	-15.33%	18.81%
2020	85.21%	22.18%	150.61%	26.78%	123.39%	22.63%	113.97%	22.36%
Cum. BHR	5267.14%		11417.14%		5813.53%		5560.73%	
AAR	22.18%		26.78%		22.63%		22.36%	
St.Dev	54.78%		62.65%		56.52%		54.35%	
Sharpe	37.22%		41.53%		38.67%		39.73%	
Max.	170.96%		180.19%		5813.53%		152.18%	
Min.	-32.37%		-31.70%		-34.44%		-35.80%	

four strategies show the B1 strategy earns better return after controlling the risk. Taking the condition of increasing F-score in the procedure increases 4.6% return.

4.2 One-year observation

Since the one-year F-score seems to be a good filtering rule, we observe the different selection strategies

Table 3
Performance of strategy C, D, and E on one-year F-score base

The performance of strategy C, D, and E with one-year and increasing F-score are reported. The strategy C1 (D1, E1) uses P/E (momentum, firm size) as the third filtering indicator. For making comparison, we also report the result of B1.

Type	B1		C1		D1		E1	
Year	BHR	AAR	BHR	AAR	BHR	AAR	BHR	AAR
2001	9.76%	9.76%	26.95%	26.95%	25.19%	25.19%	1.23%	1.23%
2002	36.77%	22.53%	53.13%	39.43%	-4.83%	9.15%	31.37%	15.32%
2003	141.55%	53.63%	94.20%	55.71%	133.03%	40.55%	144.89%	48.23%
2004	-23.09%	29.23%	-21.91%	31.04%	-25.01%	20.12%	-17.66%	27.97%
2005	-10.59%	20.05%	4.74%	25.29%	7.81%	17.55%	-14.86%	17.95%
2006	84.45%	28.96%	50.04%	29.12%	66.24%	24.54%	84.11%	27.04%
2007	1.34%	24.59%	3.99%	25.18%	3.09%	21.22%	-4.50%	21.96%
2008	-31.70%	15.57%	-39.96%	14.20%	-21.15%	14.88%	-22.65%	15.21%
2009	180.19%	27.52%	208.12%	27.51%	203.96%	27.99%	209.83%	28.60%
2010	42.83%	28.98%	74.33%	31.57%	43.63%	29.48%	39.87%	29.68%
2011	-21.83%	23.24%	-19.08%	25.88%	-17.45%	24.29%	-21.96%	23.83%
2012	16.74%	22.68%	21.19%	25.48%	31.53%	24.87%	20.92%	23.59%
2013	87.25%	26.74%	53.02%	27.41%	48.24%	26.53%	111.66%	28.81%
2014	20.80%	26.31%	21.36%	26.97%	14.50%	25.63%	-2.51%	26.27%
2015	-8.47%	23.62%	5.09%	25.38%	4.37%	24.09%	-0.25%	24.30%
2016	86.57%	26.84%	28.33%	25.56%	110.57%	28.26%	112.79%	28.55%
2017	9.65%	25.76%	15.25%	24.93%	11.43%	27.20%	15.62%	27.75%
2018	9.56%	24.80%	5.11%	23.74%	26.70%	27.17%	15.96%	27.07%
2019	-14.82%	22.32%	-5.90%	21.97%	-13.04%	24.66%	-27.99%	23.32%
2020	150.61%	26.78%	193.45%	27.44%	151.55%	29.11%	210.74%	29.16%
Cum. BHR	11417.14%		12665.90%		16463.13%		16582.62%	
AAR	26.78%		27.44%		29.11%		29.16%	
St.Dev	62.65%		64.38%		63.00%		75.48%	
Sharpe	41.53%		41.42%		44.98%		37.61%	
Max.	180.19%		208.12%		203.96%		209.83%	
Min.	-31.70%		-39.96%		-25.01%		-27.99%	

based on one-year F-score. Table 3 presents performance of C, D, and E strategies. We can see the strategy C1 (27.44%), D1 (29.11%), and E1 (29.16%) all perform better than the strategy B1 (26.78%). Such findings indicate the third indicator is suggestive for having a higher return. After adjusting by the risk factor (standard deviation), the Sharpe ratio for strategy C1 (41.42%) and D1 (44.98%) still outperform B1 (41.53%). Comparing to the indicator of firm size, the P/E and momentum seems to offer a stable suggestion.

4.3 Two-year F-score

We apply the two-year F-score to different strategies. The performances for the diverse strategy are reported in Table 4. The C2 (27.68%) strategy outperform the other three. The same scenario can be found in the case of Sharpe ratio (44.18%). We show the use of third indicator can improve the performance of value investing no matter how long the observation period is.

Table 4

Performance of strategy B, C, D, and E on two-year F-score base

This table reports the value investing strategy of B, C, D, and E using the two-year F-score as a sorting factor.

Type	B2		C2		D2		E2	
Year	BHR	AAR	BHR	AAR	Year	BHR	AAR	BHR
2001	10.60%	10.60%	26.95%	26.95%	29.00%	29.00%	5.37%	5.37%
2002	28.79%	19.35%	62.75%	43.74%	-6.20%	10.00%	21.93%	13.35%
2003	110.11%	44.11%	94.20%	58.90%	67.62%	26.58%	117.43%	40.84%
2004	-32.15%	19.37%	-15.00%	35.90%	-34.44%	7.38%	-41.90%	12.87%
2005	-0.56%	15.09%	14.35%	31.28%	7.33%	7.37%	2.51%	10.72%
2006	75.03%	23.42%	50.04%	34.24%	66.24%	15.49%	84.11%	20.51%
2007	2.77%	20.23%	15.26%	31.35%	9.21%	14.57%	-8.44%	15.87%
2008	-35.14%	11.31%	-43.53%	18.19%	-30.40%	7.65%	-20.28%	10.58%
2009	180.19%	23.33%	208.12%	31.47%	203.96%	20.81%	209.83%	23.99%
2010	40.25%	24.92%	65.84%	34.56%	51.11%	23.54%	25.36%	24.13%
2011	-19.73%	20.00%	-14.93%	29.07%	-10.39%	19.99%	-18.09%	19.53%
2012	17.55%	19.79%	28.16%	28.99%	31.53%	20.91%	15.57%	19.19%
2013	59.64%	22.47%	53.02%	30.70%	66.20%	23.90%	56.43%	21.71%
2014	25.85%	22.71%	32.54%	30.83%	16.27%	23.34%	13.64%	21.11%
2015	-6.63%	20.49%	4.41%	28.88%	-2.46%	21.43%	-2.76%	19.36%
2016	79.71%	23.54%	17.97%	28.17%	105.87%	25.50%	111.32%	23.69%
2017	6.21%	22.45%	3.30%	26.55%	5.65%	24.24%	8.74%	22.76%
2018	-1.87%	20.95%	3.75%	25.16%	12.21%	23.54%	5.00%	21.70%
2019	-13.75%	18.82%	-12.52%	22.82%	-4.46%	21.88%	-26.72%	18.49%
2020	123.39%	22.63%	166.93%	27.68%	173.29%	26.90%	151.75%	23.04%
Cum. BHR	5813.53%		13165.17%		11623.69%		6225.24%	
AAR	22.63%		27.68%		26.90%		23.04%	
St.Dev	56.52%		60.92%		62.76%		66.18%	
Sharpe	38.67%		44.18%		41.63%		33.65%	
Max.	180.19%		208.12%		203.96%		209.83%	
Min.	-35.14%		-43.53%		-34.44%		-41.90%	

4.4 Three-year F-score

We apply the three-year F-score to different strategies. The performances for the diverse strategy are reported in Table 5. Most of them perform better than the strategy A but not than the two-year F-score method in general. It is possible that firms might not be undervalued for that long. The long run F-score is less informative.

Table 5
Performance of strategy B, C, D, and E on three-year F-score base

This table reports the value investing strategy of B, C, D, and E using the three-year F-score as a sorting factor.

Type	B3		C3		D3		E3	
Year	BHR	AAR	BHR	AAR	Year	BHR	AAR	BHR
2001	14.09%	14.09%	26.95%	26.95%	29.00%	29.00%	1.23%	1.23%
2002	17.48%	15.77%	-1.60%	11.77%	25.91%	27.45%	48.49%	22.61%
2003	152.18%	50.08%	70.80%	28.74%	81.72%	43.44%	120.46%	49.09%
2004	-19.94%	28.26%	-13.29%	16.62%	-12.79%	26.66%	-21.42%	27.03%
2005	-0.32%	21.95%	14.35%	16.16%	12.06%	23.60%	5.32%	22.36%
2006	56.90%	27.18%	58.14%	22.29%	50.71%	27.75%	59.83%	27.93%
2007	10.40%	24.64%	12.91%	20.91%	13.78%	25.65%	11.86%	25.50%
2008	-35.80%	14.72%	-41.86%	10.33%	-25.56%	17.70%	-21.90%	18.28%
2009	148.36%	25.00%	159.46%	21.33%	203.96%	30.78%	168.45%	29.55%
2010	40.15%	26.44%	67.24%	25.29%	54.07%	32.94%	23.59%	28.94%
2011	-6.79%	22.98%	-14.93%	20.95%	13.21%	31.01%	4.54%	26.51%
2012	27.58%	23.36%	31.92%	21.83%	14.63%	29.56%	38.96%	27.50%
2013	49.76%	25.21%	53.02%	23.99%	66.20%	32.07%	36.67%	28.18%
2014	12.36%	24.25%	16.86%	23.46%	12.57%	30.57%	9.95%	26.79%
2015	-12.21%	21.40%	-16.37%	20.30%	-15.76%	26.81%	-12.19%	23.72%
2016	81.66%	24.50%	6.44%	19.38%	106.03%	30.72%	111.32%	27.93%
2017	3.22%	23.13%	-6.03%	17.71%	3.76%	28.95%	-8.66%	25.42%
2018	-9.15%	21.07%	3.75%	16.89%	0.77%	27.20%	-9.56%	23.16%
2019	-15.33%	18.81%	-19.61%	14.61%	-9.95%	24.91%	-33.81%	19.20%
2020	113.97%	22.36%	97.36%	17.77%	97.36%	27.80%	115.44%	22.78%
Cum. BHR	5560.73%		2533.15%		13400.15%		5962.92%	
AAR	22.36%		17.77%		27.80%		22.78%	
St.Dev	54.35%		47.66%		54.49%		56.01%	
Sharpe	39.73%		35.66%		49.60%		39.30%	
Max.	152.18%		208.12%		203.96%		168.45%	
Min.	-35.80%		-43.53%		-25.56%		-33.81%	

The B1, D1, C2, and D3 value investing strategies perform relatively better. Their AARs associate positively with the Sharpe ratio, consisting with the risk and return relationship. Obviously, the more indicators are applied in the procedure, the more time consuming and the less candidates are found. For example, about 50 samples can

be obtained from the first filtering. Then, 10 samples can be handled after applying the criteria of increasing F-score. Finally, we might not get sufficient targets from the 10 selected samples when the third indicator (e.g., P/E, momentum, and firm size) is applied. In this study, we collect at least 5 from the 10 samples. The problem of insufficient samples might not make a good statistical comparison. Also, it might not be accepted by institutional investors since they won't bet on few stocks. However, it is good for retail investors who are supposed not to have sufficient capital to conduct diversification. In addition, our setting on buy-and-hold investment is one-year. That is suggestive to retail investors especially on the idea of less trading frequency.

4.5 Sensitivity analysis

Piotroski (2000) argues that two-year holding outperforms the one-year holding on value investing. It is possible that the undervaluation can't be found by investors due to short of market information or they are less willing to hold specific stocks over a long period of time. This study goes further to test the two-year buy-and-hold performance for the 13 strategies. The selected value stocks based on the 13 strategies will be long on April, 1 and be shorted on March 31 two years later. Table 6 reports the results for the strategy of B, C, D, and E using one-year F-score.

Table 6

Two-year buy-and-hold performance of strategy B, C, D, and E on one-year F-score base

This table reports the value investing strategy of B, C, D, and E using one-year F-score as a sorting factor and holding for two-years.

Type	B1		C1		D1		E1	
Year	BHR	AAR	BHR	AAR	Year	BHR	AAR	BHR
2001	14.98%	14.98%	41.00%	41.00%	32.66%	32.66%	18.63%	18.63%
2002	0.00%	7.23%	0.00%	18.74%	0.00%	15.18%	0.00%	8.92%
2003	74.32%	26.08%	61.15%	31.47%	97.12%	37.77%	63.25%	24.65%
2004	0.00%	18.98%	0.00%	22.77%	0.00%	27.17%	0.00%	17.97%
2005	28.20%	20.77%	48.28%	27.50%	75.59%	35.64%	34.94%	21.18%
2006	0.00%	17.03%	0.00%	22.44%	0.00%	28.92%	0.00%	17.36%
2007	-27.10%	9.38%	-17.14%	15.80%	-27.93%	18.65%	-32.14%	8.53%
2008	0.00%	8.16%	0.00%	13.69%	0.00%	16.14%	0.00%	7.42%
2009	243.59%	22.98%	433.79%	35.01%	384.91%	36.12%	215.60%	21.09%
2010	0.00%	20.47%	0.00%	31.02%	0.00%	31.99%	0.00%	18.79%
2011	-18.77%	16.23%	-10.25%	26.59%	-13.19%	27.06%	-17.02%	14.98%
2012	0.00%	14.78%	0.00%	24.12%	0.00%	24.55%	0.00%	13.65%
2013	90.03%	19.32%	67.38%	27.01%	57.90%	26.84%	139.30%	20.35%
2014	0.00%	17.82%	0.00%	24.86%	0.00%	24.70%	0.00%	18.77%
2015	35.66%	18.93%	64.95%	27.20%	74.85%	27.55%	56.42%	20.97%

2016	0.00%	17.65%	0.00%	25.30%	0.00%	25.62%	0.00%	19.54%
2017	7.16%	17.01%	10.43%	24.37%	-1.58%	23.83%	4.13%	18.57%
2018	0.00%	15.99%	0.00%	22.88%	0.00%	22.37%	0.00%	17.46%
2019	84.31%	18.85%	68.12%	24.92%	125.49%	26.37%	77.09%	20.02%
2020	0.00%	17.83%	0.00%	23.54%	0.00%	24.90%	0.00%	18.93%
Cum. BHR		2561.61%		6755.52%		8435.83%		3105.90%
AAR		17.83%		23.54%		24.90%		18.93%
St.Dev		78.29%		129.48%		384.91%		74.94%
Sharpe		21.79%		17.58%		20.47%		24.24%
Max.		243.59%		433.79%		203.96%		215.60%
Min.		-27.10%		-17.14%		-27.93%		-32.14%

For making a clear comparison, we list the results of AAR and the Sharpe ratio of the strategies that is hold for one or two years in Table 7. For saving space, we only report the detail in the case of one-year F-score and present the summary.

Table 7

The AAR and Sharpe ratio for the B, C, D, E value investing

This table reports the AAR and Sharpe ratio for B, C, D, and E value investing with different selection criteria. The holding period for the portfolio is one- or two-year.

Type	B1	C1	D1	E1
AAR				
One year holding	26.78%	27.44%	29.11%	29.16%
Two years holding	17.83%	23.54%	24.90%	18.93%
Sharpe ratio				
One year holding	37.22%	41.53%	41.42%	44.98%
Two years holding	21.79%	17.58%	20.47%	24.24%
Type	B2	C2	D2	E2
AAR				
One year holding	22.63%	27.68%	26.90%	23.04%
Two years holding	13.12%	15.44%	14.29%	11.75%
Sharpe ratio				
One year holding	38.67%	44.18%	41.63%	33.65%
Two years holding	26.27%	45.74%	32.29%	25.66%
Type	B3	C3	D3	E3
AAR				

One year holding	22.36%	17.77%	27.80%	22.78%
Two years holding	16.28%	20.45%	20.65%	12.98%
Sharpe ratio				
One year holding	39.73%	35.66%	49.60%	39.30%
Two years holding	19.87%	18.48%	17.13%	18.78%

It is obvious that the two-year buy-and-hold strategy doesn't perform better than the one-year holding. That is, the Taiwan stock market might be somewhat efficient. The undervaluation can be found by investors. This idea consists with the finding that using two- or three-year F-score might not be suggestive since the mispricing can be corrected in about one year. The value investing should not be applied in a very long run in Taiwan

5. Conclusion

This study uses Taiwan data from 2000 to 2020 to examine the performance of value investing. The idea of value investing is to find out the value stocks using the financial data disclosure by the firms. Since not all high BM firms (about 44%) have better performance (Piotroski, 2000), we modify the selection procedure of Piotroski (2000) by three ways to optimize the selection process. First, we apply a condition of increasing F-score that guarantees the firm is improved at the time of decision making rather than just a good candidate. Second, we use a long-term observation to measure the financial performance of value stocks for having a more solid measurement. Finally, we apply P/E, momentum, and firm size as the third indicator to refine the selected candidates. In sum, we test the performance by 13 value stock selection strategies.

Our findings show the application of third indicator improves the performance of portfolio. The annualized rate of return for applying increasing F-score principle in the process is 4.6% higher than the method proposed by Piotroski (2000). However, the use of two- or three-year F-score evaluation doesn't help a lot. It is possible that market will discover the mispricing within one year. Stocks that have been long undervalued might not be mispriced. The performance becomes better when the third indicator is applied. The annualized return is about 27.44%, 29.11%, and 29.16% when P/E, momentum, and firm size is used respectively. This study also extends the holding period from one to two-year. However, the results differ from the finding of Piotroski (2000). This finding indicates the mispricing will be corrected. Holding over a long period is not suggested in Taiwan.

Our modification is suggestive to retail investors who in general trade frequently and suffer from the transaction cost and handling fee. The contributions are threefold. First, the buy-and-hold return is significant high in 2008, showing the method can capture the value stocks efficiently during the financial crisis period. Second, the selection process doesn't yield many candidates in every year, allowing retail investors to conduct long-term investment. Finally, we disclosure the more indicator used in the selection providing better suggestion. The

mispricing can be figure out within one year. That displays the difference cross markets.

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