

Portfolio Selection Based on a Four-Dimensional Weighted Scoring Model

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Abstract. Although factor investment approaches are currently receiving a lot of attention, active investment strategies rarely apply the combination of different factors. This paper's major goal is to utilise a clearly defined model to assess if the portfolio chosen by the model offers superior total returns compared to standard indexes (S&P 100 is taken as an example in this article). The author constructs a weighted scoring model combining different indicators to well demonstrate four factors based on the identification of valuation, profitability, growth and pay-out. This paper collects data of high-capitalization corporates in US during the period from 2015 to 2021 to illustrate that an active management portfolio well designed by the weighted scoring model can outperform competing index strategies. The reported results illustrate that combined precisely weighted indicators deliver significant outcome of selected stocks, especially in the long-term condition. The 5-year return of the selected portfolio, which is determined by the model constructed, delivers the outstanding performance with returns of up to about 180%.

Keywords: Portfolio selection; Stock analysis; Four-dimensional weighted scoring model; Better performance

1. Introduction

An intriguing aspect of trading process in the financial markets is the problem of stock selection. The final portfolio produced by its manager often contain only a small proportion of those stocks provided [1]. According to Binay (2005), the investment style choice of the institution can be the main reason of most of the portfolio returns generated, however, the results illustrate that outstanding stock selection skills have helped increase portfolio performance comprehensively [2]. As Chen et al (2013) said, the theory of portfolio selection aims to rank the target stocks and determine the asset allocations in the capital market [3]. Thus, the final composition of portfolios that investors selected ultimately determines the actual return that investors can benefit from their investments. As a result, the critical factor is how stocks are picked to better the final output of portfolios. Existing evidence reveals that valuation, profitability, growth and pay-out policy in the fundamental aspects of a stock contribute a lot to the ultimate return of a stock.

Valuation of a company is a set of procedures, which are used to reckon the practical value of a company. That is, valuation of a company equals how much investors are willing to pay for the shares of a company. Hence, valuation is the most crucial factor that investors are ought to consider when selecting a target stock. Here many valuation techniques are created, such as price to asset (P/E) ratio or price to book (P/B) ratio. These precisely calculated ratios are all comparable accurate reflection to whether a stock is over-estimated or under-estimated and provides an intuitive decision-making strategy to investors. The profitability of a company is significantly crucial, too. How to make money and maximize the revenue are goals of any business. While some growing companies are able to bear the pressure of operating at a loss for several years, every business needs to become profitable. According to Bermejo et al. (2021), the inclusion of profitability when selecting stocks permits value investors to differentiate between underpriced stocks (stocks that with a traded price well below fundamentals) and those are called value traps (stocks that are cheap due to low intrinsic values) [4]. Profitability is measured to analyzing whether a company can continue to operate in its current capacity.

When evaluating a typical stock, the growth of a company is always significant since it indicates the future performance on the stocks trade price. Zhang, Gao and An (2018) displayed that the stock

price would increase with a relative higher probability when the historical stock price was in an uptrend step [5]. The steady growth can typically generate significant positive cash flows or earnings, which helps growing companies to have very profitable reinvestment opportunities for its own retained earnings, indirectly improving returns to investors. The pay-out ratio is a financial metric illustrating the percentage of incomes a company pays its investors in the form of dividends. The pay-out ratio is one of the key financial factors utilized to determine whether a company's dividend payment program is sustainable. With the rapid changes occurred in stocks prices, the pay-out ratio is the stable benefits that investors will directly have.

Overall, the most classical and common approach to evaluate the performance of a stock is mostly based on these four aspects. Active and passive portfolio strategies are two opposite ways for investors to manage their money. The passive strategy is to copy the market index (like S&P 500) and get the return similar to exact market index's return, while the active portfolio strategy is more likely to achieve higher return than the market. Yang and Huang (2022) showed that mutual funds with a higher proportion of actively managed funds outperform peer funds with a low percentage of actively managed funds over year 1993 to 2015 [6]. Besides, according to Chou et al. (2022), an increasing number of people treat investments not only to enhance their own wealth but also to hedge against the risk of inflation [7]. Therefore, the most urgent affair is to decide an actively managed portfolio to help investors handling their money.

2. Methodology

According to Trancar (2014), the stock price is affected by numerous factors, included in the arguments of a fundamental analysis, such as the profit, reputation, degree of risk, the effect of monetary policies, fiscal policies, macroeconomic aggregates' impact, and the cyclical phases of the global economy [8]. This article provides a concise weighted scoring model (WSM) to solve the practical problems that investors are likely to encounter during the process of which stock to invest. The weighted scoring model, developed by Stanley Zionts, originates from the multiple criteria decisions making (MCDM) mathematical model in 1979 [9]. In the MCDM mathematical model, the objective was decision-making when multiple criteria are active. Therefore, the benefits of each decision were compared and ranked based on various criteria.

Considering m alternatives $\{A_1, A_2, \dots, A_m\}$ with n deterministic criteria $\{C_1, C_2, \dots, C_n\}$, the alternatives are totally represented by decision matrix $\{S_{ij}\}$, where S_{ij} is the score that measures how well alternative A_i performs on criterion C_j . In order to represent the importance ranking of different criteria, the weights $\{W_1, W_2, \dots, W_k\}$ are defined as the proportion of each criterion. In WSM, the ultimate score for alternative A_i is calculated using the formula (1), as follows.

$$S(A_i) = \sum W_j * S_{ij} \quad (1)$$

Where sum is over $j = 1, 2, \dots, n$, and W_j is relative importance of j th criterion. Considering a weighted scoring model which contains four different aspects for company analysis (valuation, profitability, growth and pay-out), each of these factors can be measured by the corresponding indicators specifically, as follows.

In terms of the valuation of a company, the price-to-earnings ratio for the stock indicates how much value the stock currently puts on its profits. P/E ratio is defined as the fraction of the exact price (market value) of one share of a stock divided by the earnings per share (EPS). In other words, Anderson (1997) illustrated that personal investors and institutions tend to accept a premium capital expenditure to lock in on a company's profits, tying the company's market price to a multiple based on the company's earnings per share [10]. It can be concluded that the valuation of a stock can be properly measured by P/E ratio according to its definition. The second indicator from various stock studies to decide whether to contain a stock in a portfolio or not is gross profit to assets value (GP/A), which generates the likelihood that the final portfolio will be rather profitable in case of taking it as

a consideration. The gross profit to assets value is a manifestation of the efficiency and capacity that a company uses assets to generate gross profit, measuring the profitability of a company. The revenue growth rate of a company, which represents the ratio of revenue growth through a typical period divided by the time horizon (usually by year), can be calculated through comparing the P/E ratio and GP/A. Generally, the growth of a firm can be properly measured by its revenue growth rate because the revenue usually directly reveals the growth of the company. The approach to measure the pay-out of a company is to calculate its dividend yield. According to Monteiro, Sebastião and Silva (2020), stock returns can be strongly forecasted by dividend yield, which is verified by previous studies [11]. In addition, dividend yield precisely indicates the dividend that investors will benefit from per unit of asset since dividend yield is obtained by dividend per share of a stock divided by its one share price.

After ascertaining the indicators of each aspects decided to consider, the point of designing a model is to combine these indicators together to ultimately bring out the wanted synergetic effects. Due to the fact that there exists mutual effect among individual indicators, it has to pick just one indicator to quantify four dimensions of a company's performance respectively. This leads to the phenomenon where each independent indicator illustrates a better prognosis of stock price movement than combination of all the indicators together. Also, monitoring single indicator in isolation is improper since the disadvantages of one indicator is equivalent to the potential power of forecasting the stock price movement of others. Therefore, investors are ought to figure out an appropriate combination of bunch of indicators to design a valid portfolio selection model. For this purpose, the weights to the four different indicators in this article are configured individually in the Table 1.

Table 1. Criterion and Weight of Each Dimension

Dimension	Criterion	Weight
Valuation	P/E ratio	30%
Profitability	GP/A ratio	25%
Growth	Revenue growth	25%
Pay out	Dividend yield	20%

In addition, all the listed companies in the United States are divided into ten quantiles to score these stocks for each indicator from 1 to 10. As an example, for P/E ratio, it can be ranked from positive to negative, then from smallest to largest, and the positive integer is numbered from 1, 2, 3... for each stock to equally separate all stocks into 10 quantiles. After that, stocks in different quantiles are scored by respective quantile's order. Usually, the stock with the smallest positive P/E ratio is scored as 10. That means that the stocks with higher ranking should have higher score. Considering the effect of time horizon, the score is defined to have a 10% drop in the influence for every tear further from now. Total score of an individual stock is calculated by the formula (2):

$$Total\ Score = \sum W_i * S_i * 0.9^n \quad (2)$$

Where W_i is the weight of i th indicator; S_i is the score of i th indicator; n is the number of years. To test the defined weighted scoring model, the first step is to rank stocks based on each of these indicators, and then select first 10 stocks respectively to test the rationality of the model since the stocks that selected are perform well in individual indicators. After that, the total score of all these stocks is calculated, and the top 10 stocks are selected into the final portfolio. Eventually, the hypothesis is verified by comparing its return with S&P 100.

3. Results

Based on the indicators discussed before, this paper collects the data for each indicator of all listed companies in the United States from 2015 to 2021 (source: S&P 500, Bloomberg, NKBM), excluding

the companies with missing data. For each year, the stocks were ranked by every indicator described above, and the ideal solution constructed for each indicator is included the stocks with the smallest positive P/E ratio, stocks with the largest GP/A, stocks with largest revenue growth, and stocks with largest dividend yield. This paper focuses on both short-term and long-term situation to verify the validity of the weighted scoring model. For the short-term, the experiment data is selected from the data of the year of 2020 (data of the year 2021 is used to calculate the precise return of the last year), while the formula (2) specified above is used to calculate the summation of total score for each stock from 2015 to 2020 and then compared with S&P 100 index. First, all the stocks with valid data are sorted with P/E ratio, GP/A, revenue growth and dividend yield respectively. Then, top 10 stocks with highest rank are selected with data of 2020 as Table 2 shown.

Table 2. Stocks List (in Ticker Symbol) according to Four Indicators

P/E ratio	GP/A	Revenue Growth	Dividend Yield
SMLP	LFVN	LBRDK	NGL
IRCP	MED	RIOT	GLOP
CRC	WINA	QURE	TG
VHC	PRG	PLAG	WHLR
FENG	MTEX	DVAX	PATI
CYH	EDUC	BCRX	MIC
ENVA	SNBR	XSPA	SNT
LODE	USNA	OXBR	ICMB
CNNE	SJT	AXU	FRO
COHN	RCII	FUN	FF

Due to the method that these stocks are selected, each stock is scored as 10 for respective indicators. For example, SMLP gets a 10 score for P/E ratio, and stock LFVN gets a 10 score for GP/A. Therefore, all stocks are generated with specific scores as Table 3:

Table 3. Scores of Different Indicators in 2020

tic	P/E score	GP/A score	Revenue Growth score	Dividend Yield score
SMLP	10	5	4	6
IRCP	10	4	1	10
CRC	10	1	7	5
VHC	10	2	1	10
FENG	10	8	2	10
CYH	10	5	4	5
ENVA	10	7	9	1
LODE	10	1	10	2
CNNE	10	1	7	5
COHN	10	2	5	6
LFVN	8	10	2	5
MED	8	10	9	8
WINA	8	10	6	8
PRG	9	10	4	6
MTEX	10	10	4	10
EDUC	10	10	1	8
SNBR	9	10	6	2
USNA	9	10	4	2
SJT	9	10	10	10
RCII	10	10	9	9
LBRDK	6	2	10	5
RIOT	5	3	10	2

QURE	3	1	10	1
PLAG	10	5	10	2
DVAX	2	1	10	2
BCRX	3	1	10	4
XSPA	1	1	10	6
OXBR	5	6	10	5
AXU	3	2	10	1
FUN	2	1	10	8
NGL	1	6	9	10
GLOP	10	5	2	10
TG	4	9	5	10
WHLR	1	4	3	10
PATI	6	8	2	10
MIC	4	5	1	10
SNT	5	9	1	10
ICMB	1	5	1	10
FRO	10	6	1	10
FF	9	5	9	10

By the formulas discussed in methodology section, scores for each indicator are weighted. Then, final scores can be generated in Table 4 and the top 10 stocks are picked as final portfolio in Table 5.

Table 4. Final Scores for Stocks in 2020

tic	final score	tic	final score	tic	final score	tic	final score
SMLP	6.45	LFVN	6.4	LBRDK	5.8	NGL	6.05
IRCP	6.25	MED	8.75	RIOT	5.15	GLOP	6.75
CRC	6	WINA	8	QURE	3.85	TG	6.7
VHC	5.75	PRG	7.4	PLAG	7.15	WHLR	4.05
FENG	7.5	MTEX	8.5	DVAX	3.75	PATI	6.3
CYH	6.25	EDUC	7.35	BCRX	4.45	MIC	4.7
ENVA	7.2	SNBR	7.1	XSPA	4.25	SNT	6
LODE	6.15	USNA	6.6	OXBR	6.5	ICMB	3.8
CNNE	6	SJT	9.7	AXU	4.1	FRO	6.75
COHN	5.95	RCII	9.55	FUN	4.95	FF	8.2

Table 5. Final Portfolio according to Final Scores in 2020

2020-2021	Company	tic	final score	stock price in 2020	stock price in 2021
Portfolio	San Juan Basin Royalty Tr	SJT	9.7	2.67	6.09
	Rent-A-Center Inc	RCII	9.55	38.29	48.04
	Medifast Inc	MED	8.75	196.34	209.43
	Mannatech Inc	MTEX	8.5	18.6	38.32
	Futurefuel Corp	FF	8.2	12.7	7.64
	Winmark Corp	WINA	8	185.8	248.29
	Phoenix New Media Ltd -Adr	FENG	7.5	1.2	0.862
	Prog Holdings Inc	PRG	7.4	53.87	45.11
	Educational Development Corp	EDUC	7.35	15.61	7.88
	Enova International Inc	ENVA	7.2	24.77	40.96
Sum				549.85	652.622

As Table 5 demonstrates, the final portfolio for 2020 consists of the best 10 stocks based on the weighted scoring model, thus, the final portfolio represents the selection of stocks based on all four aspects of a company. The result of the selected portfolio is statistically significant, especially compared to the exact return of S&P 100 in 2020. The portfolio return, counted by equally weighted method (same method used to calculate S&P 100 index), is 18.69% and significantly higher than the amount of S&P 100 index (11.04%). It can be concluded that the short-term efficiency of the weighted scoring model can be proven based on the latest one year's data. Nevertheless, the validity for long-term situation about the scoring model is still doubtful. To figure out this problem, the scores for each of these 40 selected stocks in the last 5 years are calculated to rebuild the best final portfolio through the same methodology. However, a 10% drop in the influence for the scores in the former years to the following year was counted. Table 6 shows the specific scores for each stock for each year, calculated by the formula (2). After sorting the final score for all the stocks, the new portfolio has been generated as Table 7.

Table 6. Scores of Stocks from 2015 to 2020

tic	final score in 2020	final score in 2019	final score in 2018	final score in 2017	final score in 2016	final score in 2015	total final score
MED	8.75	9	8.4	8.6	7.4	6.95	38.88
SJT	9.7	7.7	7.05	7.3	9.25	7.35	38.07
EDUC	7.35	9.8	7.25	7.45	7.75	8.55	37.61
PRG	7.4	5.25	7.2	8.3	7.45	7.45	33.29
GLOP	6.75	4.9	7.3	7.6	8.45	8.15	32.97
RCII	9.55	8.7	5.5	5.8	5.4	5.35	32.77
MTEX	8.5	8.05	5.85	5.95	5.5	6.8	32.44
SNBR	7.1	7.3	6.75	6.15	6.9	6.95	32.25
WINA	8	6.65	6.4	6.65	6.65	6.35	32.13
FF	8.2	7.15	5.2	5.85	7.55	5.5	31.31
ENVA	7.2	5.25	6.5	6.9	7.05	7.35	31.19
FUN	4.95	6.3	7.85	7.2	7.2	7.05	31.11
LFVN	6.4	7.15	7.4	5.45	5.4	7.9	31.01
USNA	6.6	7	5.2	6.7	6.55	7.2	30.55
TG	6.7	6.2	5.95	7.4	6.95	5.2	30.12
FRO	6.75	7.35	4.9	5.35	6.05	7.9	29.87
IRCP	6.25	3.45	7.9	5.2	7.3	5.75	27.73
PATI	6.3	5.4	5.9	5.2	6.15	5.75	27.16
NGL	6.05	4.1	4.3	6.45	7.7	5.85	26.43
SMLP	6.45	4.4	4.6	6.2	6.4	5.85	26.31
SNT	6	5.25	4.65	6.55	4.45	6.6	26.08
FENG	7.5	6.65	4.55	3.5	6.05	4.05	26.08
ICMB	3.8	5.55	5.8	8.2	4.05	6.15	25.76
COHN	5.95	5.75	4.2	6.2	5.3	5.45	25.74
MIC	4.7	5.05	5.4	6.1	6.3	5.35	25.36
OXBR	6.5	5.45	1.8	2.8	7.65	8.75	25.09
CRC	6	3.55	5.6	5.5	7	2.2	23.63
LBRDK	5.8	5.75	4.3	5.2	4.1	3.6	23.06
WHLR	4.05	4.5	3.9	4.8	5.7	5.75	21.89
PLAG	7.15	2.8	3.7	3.85	1.95	4.45	19.38
VHC	5.75	4.65	4.1	2.95	2.8	3.3	19.19
XSPA	4.25	3.75	4.15	3.7	5.25	2.85	18.81
CYH	6.25	3.7	2.9	2.65	2.6	4.95	18.49
RIOT	5.15	4.15	2.5	5.55	4.15	1.2	18.39
CNNE	6	3.3	3.1	3.2	2.85	3.4	17.69
LODE	6.15	3.3	3.3	3.9	1.45	2.95	17.33

DVAX	3.75	3.85	4.15	4.15	1.2	4.15	16.84
AXU	4.1	2.25	4.9	4.65	2.5	1.95	16.28
BCRX	4.45	1.85	4.8	1.65	2.2	1.9	13.77
QURE	3.85	4.45	1.5	1.25	1	3.95	12.97

Table 7. Final Portfolio under Long-Term Situation

2015-2021	Company	tic	stock price in 2015	stock price in 2021
portfolio	Medifast Inc	MED	30.38	209.43
	San Juan Basin Royalty Tr	SJT	4.14	6.09
	Educational Development Corp	EDUC	11.34	7.88
	Prog Holdings Inc	PRG	22.39	45.11
	Gaslog Partners Lp	GLOP	14.22	4.26
	Rent-A-Center Inc	RCII	14.97	48.04
	Mannatech Inc	MTEX	18.85	38.32
	Sleep Number Corp	SNBR	21.41	76.6
	Winmark Corp	WINA	93.01	248.29
	Futurefuel Corp	FF	13.5	7.64
Sum			244.21	691.66

Table8. S&P100 Yearly Return from 2015 to 2020

Year	2020	2019	2018	2017	2016	2015
Return	11.04%	25.74%	-8.55%	17.42%	10.01%	-2.94%

According to the same methodology, 10 stocks were chosen for the final portfolio from 2015 to 2020. Illustrated in Table 7, the portfolio return is extremely high, reaches 183.22%. Compared with S&P 100 index's return during the time horizon, which is 60.085% and can be calculated by the Table 8, the portfolio determined by the weighted scoring model achieved returns almost three times of those accessed by investing in S&P 100 index.

4. Discussion

The findings for the whole sample in this paper can be summarized as follows: First, the four determinants, valuation, profitability, growth and pay out policy, delivers a comprehensive coverage of company fundamentals and comparative advantages, while the indicators used in this scoring model explains only a single aspect of these dimensions of the fundamentals of a company. Nevertheless, the main significance of these dimensions can still be roughly interpreted by those ratios. Second, the impact of different factors on portfolio returns differs. Comparing Table 3 and Table 4, the top 10 stocks with highest final score are mostly selected with the determents of highest Gross Profit to Asset ratio, even GP/A does not contribute the most proportion to the final score, only 25%, and stocks with highest growth rate are less likely to rise to the top. Lastly, the validity of the designed model would not be affected by the time horizon. Both short-term and long-term analysis are suitable for constructing a portfolio establish mechanism.

5. Conclusion

Regarding the design of final portfolios, the most vital part is including all the four dimensions in the weighted scoring model, which analyses the fundamental aspect of typical stocks as well as the historical performance of economic trends and structural factors. The purpose of designing the weighted scoring model is maximum the overall return for investors and fund managers. Although the designed model regardless of the risk factors, psychological factors and so on, the ultimate result

is mostly within our expectation. In principle, the analytical method to determine the model is only as flexible as analysts or portfolio managers, who can be aware of more factors that will affect stock price.

In conclusion, the empirical result from the research was based on the two different horizons and analysed from four different indicators corresponding to respective aspects. Taking each indicator as a dominant factor, top 10 stocks are selected from all stocks listed in the United States. Then, total 40 selected stocks are scored by the designed model to help investors ranking. Eventually, top 10 stocks are selected among these 40 elite stocks as a final equally weighted portfolio. Overall, the known criteria (P/E, GP/A, revenue growth, and dividend yield) are all precisely weighted for the selection of stocks. Ultimately, the chosen stock selection model can be used not only for the American capital market but other capital markets. Also, it is essential that the origin data reflects the actual situation of the company and the economy as well, especially as there are fund managers and individual investors generating their own weighted scoring models.

References

- [1] Duxbury D., Huston R., Keasey K., Yang Zhishu, Yao Songyao. How prior realized outcomes affect portfolio decisions. *Review of Quantitative Finance & Accounting*, 2013, 41(1): 611-629.
- [2] Binay M. Performance attribution of US institutional investors. *Financial Management*, 2005, 34(2): 127–152.
- [3] Chen, Li, Li Benli, Dong Shangjia, Pan Heping. A Combined cfahp-ftopsis approach for portfolio selection. *China Finance Review International*, 2013, 3(4): 381–395.
- [4] Bermejo B., Figuerola-Ferretti I., Hevia T., Santos A. Factor investing: A stock selection methodology for the European equity market. *Heliyon*, 2021, 7(10), e08168–e08168.
- [5] Zhang, Yi, Gao Jinwu, An Qi. International investing in uncertain financial market. *Soft Computing* (Berlin, Germany), 2018, 22(16): 5335–5346.
- [6] Yang Tingting, Huang Xiaoxia. Active or passive portfolio: a tracking error analysis under uncertainty theory. *International Review Of Economics & Finance*, 2022, 80(1): 309–326.
- [7] Chou YaoHsin, Jiang YuChi, Hsu YiRui, Kuo ShuYu, Kuo SyYen. A weighted portfolio optimization model based on the trend ratio, Emotion Index, and Angqts. *IEEE Transactions on Emerging Topics in Computational Intelligence*, 2022, 6(4): 867–882.
- [8] Trančar V. The effect of the combination of different methods of stock analysis on portfolio performance. *Nase Gospodarstvo (English)*, 2015, 61(1): 37–50.
- [9] Zionts S. Multiple criteria Decision making for discrete alternatives with ordinal criteria. *Extremal Methods and Systems Analysis*, 1980, 174(1): 135-152.
- [10] Anderson, James A. 8 Stocks to bank on. *Black Enterprise*, 1997, 28(1): 93–93.
- [11] Monteiro A., Ebastiao H., Silva N. International evidence on stock returns and dividend growth predictability using dividend yields. *Revista Contabilidade & Finanças*, 2020, 31(84): 473–489.