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The Fama-French 3 Factor Model Prediction and Evaluation of Portfolio

Yangrui Deng

Monash University, Petaling Jaya, 47500, Malaysia
yden0040@student.monash.edu

ABSTRACT

This research assesses the performance of a diversified portfolio, including 20 common shares drawn from two industries, that was constructed in January 2024 and held until December 2024. It uses rigorous multi-factor approaches to evaluate each asset's risk characteristics and financial returns using historical data from 2020 to 2023. To offer empirical insights into portfolio dynamics, key indicators include total portfolio returns, standard deviation for volatility, and beta coefficients to measure susceptibility to market swings.

KEYWORDS

Multi-factor approaches; Diversified portfolio; Market swings

1. INTRODUCTION

My group was tasked with building and overseeing a common stock portfolio with an initial investment of USD 100 million. Twenty common equities from two industries—Specialty Chemicals and Pollution & Treatment Controls—make up the portfolio.

The portfolio' s objective is to maximize the Sharpe ratio.

The final portfolio is compromised by 7 stocks. Three companies come from the Pollution & Treatment Controls and four companies come from the Specialty Chemicals.

The portfolio will be evaluated by using Sharp ratio. The key constraint of the portfolio is that the sum of weight equals to 1. The benchmark is Nasdaq index.

Based on the objective and constraints, the portfolio is constructed by using the Fama-French threemodel method. The portfolio consists of 7 stocks, including ARQ, CLWT, ERII, AVTR, DD, WLK, LYB.

The holding period of portfolio is the year of 2024. The expected return of this portfolio is 20.5% and its expected risk is 20%

After the evaluation by real trading data from Yahoo finance, the actual return of portfolio is 6.72%, and actual risk is 6.49% during the first four months in 2024.

2. METHODOLOGY AND RESULTS

The core method is that using Fama-French three factors model to select the stocks and to make a prediction about each asset's and the whole portfolio's expected return and expected risk.

Additionally, we adjust it by using actual stock's and portfolio's current-to-day return and risk for four months (January to April 2024).

2.1. Selections of Data and Data Types

All the data came from the FRED website and Yahoo Finance from 2020 to 2023.

Long-term trends can be better seen by averaging the daily swings in stock prices, which is possible with monthly data. All data is chosen according to monthly frequency based on this.

2.1.1. The choice of methods

The performance of stocks and a portfolio can generally be predicted using four different approaches: the single factor model, the multi-factor model, the free cash flow model, and the statistical model. To process the forecast, our team choose to use the multi-factor (Fama-French 3 factor model).

The pros of Fama-French 3 factor model are diversification of rick source and enhanced performance attribution (Sharma & Mehta, 2013), and the cons of Fama-French 3 factor model is complexity in implementation (Sharma & Mehta, 2013).

Although the multi-factor (Fama-French 3 factor model) has its limitation, it still has incomparable advantages than other methods. It not only can reflect real-world complexity, but also has higher adjustment R square than the other single factor, in statistics.

2.1.2. The process of prediction

(1) Indicators of stock

It is necessary to calculate the expected risk and return for the stocks and portfolio. According to the Fama & French (1992, 1993, 1996), the formula is:

$$E(Ri) - Rf = \alpha + b_i, E(R_m) - R_f + s_i E(SMB) + h_i E(HML) + error$$

The regression has three components. The expected risk premium on the market portfolio is represented by the E(Rm)-Rf (factor 1). E(SMB) (factor 2) represents the size-related estimated risk premium. The estimated risk premium on growth possibilities is denoted by E(HML) (factor 3). The coefficients for the excess return, SMB, and HML of the market's portfolio are b_i (beta 1), s_i (beta 2), and h_i (beta 3). (beta 3) stands for the excess return, SMB, and HML of the market portfolio, in that order. Excel may do a multi-factor regression by obtaining these three factors from an authorised source. The precise beta values for each stock may be found by doing calculations in Excel. Additionally, the annualized alpha and firm-specific variance (Expected risk) for each stock can be derived. The risk-free rate used is the one-year risk-free rate on the day the portfolio is constructed. The expected return premium for factor 1 is calculated as the stock market's expected annual return minus the risk-free rate. The expected return premiums for factor 2 and factor 3 are the average annual values of SMB and HML, respectively. Therefore, the expected risk premium for each factor for each stock can be computed by multiplying beta 1, 2, and 3 by the respective factor's expected return premium. The expected total risk premium for each stock is the sum of the annualized alpha and the expected risk premiums from factors 1, 2, and 3. Finally, the expected return for each stock is calculated by adding the risk-free rate to the expected total risk premium.

(2) Indicators of Portfolio

The overall performance of the portfolio should be evaluated. This involves calculating the portfolio's alpha, its betas (1, 2, and 3), and the annualized variance of residuals. The portfolio's annualized standard deviation, which represents the expected risk, is determined by taking the square root of the portfolio's annualized variance. The annualized variance of the portfolio can be computed using the formula provided below:

$$\text{portfolio}^{\$}\text{s annualized variance} = ((\text{Portfolio beta } 1)\ \% * \text{The stock market's annualized variance} + \text{Portfolio's annualized variance of residuals})$$

(3) The weight of each stock

We ascertain each stock's weight after utilising the multi-factor model to evaluate the projected risk and return of every stock in our portfolio. We used the S&P 500 as a benchmark for determining these weights using the Fama-French three-factor model. This makes it easier to compare and evaluate how well specific equities have performed in relation to the market as a whole.

(4) The Sharpe ratio of portfolio

The portfolio's Sharpe ratio is calculated by dividing the portfolio's expected total annual risk premium by its annualized standard deviation. This is done under the constraint that the sum of all stock weights equals 1 to maximize the ratio.

(5) The Sharpe and Treynor ratio of assets (risk-adjusted indictors)

To start, my team needs to determine the appropriate benchmark for comparison. While the S&P 500 is widely used, selecting benchmarks tailored to specific industries can enhance the relevance of comparisons. Therefore, we opted to utilize the Nasdaq index as the benchmark for our two technology-focused stocks. I calculated the values of (Ri-Rf) and (Ri-Rm) for both the stocks and the benchmark. Using these values, I constructed a regression model with (Ri-Rm) as the dependent variable and (Rm-Rf) as the independent variable. The coefficients of the independent variables represent the beta over a four-year period. Additionally, it's necessary to compute the average (Ri-Rf) and the standard deviation of (Ri-Rf) for both the benchmarks and the stocks. We computed the Sharpe and Treynor ratio for each stock those selected by Fama-French 3 factor model.

2.1.3. The process of evaluation

(1) The Current-to-date return and risk of stock

We know that the price of all stocks in the portfolio on 2 January 2024 and on 30 April 2024. You also know the total dividends paid for each stock over the same period. Therefore, we can compute monthly return on each stock. Then, we can compute each stock's current-to-date return and risk (from 2 January 2024 to 30 April 2024)

(2) The Current-to-date return and risk of portfolio

$$Portfolio\ value = (stock\ A\text{'}s\ price\ x\ the\ number\ of\ shares) + (stock\ B\text{'}s\ price\ x\ the\ number\ of\ shares) + \dots\ ..$$

We know the value of the portfolio (including all received dividends), say, at the end of every month. The monthly return on the portfolio can be calculated. Then, we can compute the portfolio's current-to-date return and risk (from 2 January 2024 to 30 April 2024).

(3) The risk-adjusted indictors of stocks and portfolio

We know the monthly return on the portfolio and each stock for four months. we can compute the standard deviation of the monthly excess return using the four monthly returns on the portfolio and stocks. We also can use the same beta from past four data. Then we can compute the Sharpe and Treynor ratio of assets and portfolio.

2.2. Results

2.2.1. The performance of portfolio (prediction)

Table 1. The prediction of portfolio

Estimted the three-factor (general) model for 20 stocks		Exclude the market portfolio. Use the rescaled weightages	
Non-zero Alpha for some stocks			
Portfolio's expected annual return	0.1932696	Portfolio's expected annual return	0.20566272
Portfolio's expected total annual risk premium	0.1418696	Portfolio's expected total annual risk premium	0.15426272
Portfolio's expected annual risk premium on Factor 1	0.13496117	Portfolio's expected annual risk premium on Factor 1	0.13777823
Portfolio's expected annual risk premium on Factor 2	0.00209122	Portfolio's expected annual risk premium on Factor 2	0.00498995
Portfolio's expected annual risk premium on Factor 3	0.00481721	Portfolio's expected annual risk premium on Factor 3	0.01149454
Portfolio's annualized variance	0.03885706	Portfolio's annualized variance	0.04041681
Portfolio's annualized standard deviation	0.19712193	Portfolio's annualized standard deviation	0.20103931
Portfolio's Sharpe ratio	0.71970479	Portfolio's Sharpe ratio	0.76732613
Portfolio's alpha	0	Portfolio's alpha	0
Portfolio's beta 1	1.01608663	Portfolio's beta 1	1.03729553
Portfolio's beta 2	0.1110137	Portfolio's beta 2	0.26489443
Portfolio's beta 3	0.24416672	Portfolio's beta 3	0.58261643
Portfolio's annaulized variance of residuals	0.00188033	Portfolio's annaulized variance of residuals	0.00188033
Risk-free rate (per year)	0.0514	Risk-free rate (per year)	0.0514
The stock market's expected annual return	0.18422447	The stock market's expected annual return	0.18422447
The stock market's annualized variance	0.03581516	The stock market's annualized variance	0.03581516
The stock market's annualized standard deviation	0.18924895	The stock market's annualized standard deviation	0.18924895
The stock market's Sharpe ratio	0.70185053	The stock market's Sharpe ratio	0.70185053
Factor 1's expected annual risk premium	0.13282447	Factor 1's expected annual risk premium	0.13282447
Factor 2's expected annual risk premium	0.0188375	Factor 2's expected annual risk premium	0.0188375
Factor 3's expected annual risk premium	0.01972917	Factor 3's expected annual risk premium	0.01972917

The expected return and risk are 20.5% and 20.1% separately and the maximum Sharpe ratio is 0.76 which is higher than the market's Sharpe ratio, 0.70 [6].

2.2.2. The performance of stock (prediction)

The Expected Selling price follows the equation below:

$E\ (Ri)$ = !————(#!) % ! (&!) - 1 #"

The expected dividend is the average of the stock dividends from 2023.

Table 2. A portfolio of stocks as of 2 January 2024

Stock	Purchase Price	No of Shares	Weight	Expected Selling Price	Expected Dividend	Expected Return	Expected Risk
ARQ	2.99	1681372	5%	3.7076	None	0.24	19%
CLWT	15.8	474324	7.5%	17.064	None	0.08	3%
ERII	18.5	690010	12.8%	22.57	None	0.22	17%
AVTR	22.68	538419	12.2%	27.6696	None	0.22	17%
DD	76.49	146830	11.2%	92.9578	0.36	0.22	17%
WLK	140.33	197793	27.8%	167.916	0.48	0.20	16%
LYB	94.83	246933	23.4%	112.546	1.25	0.20	15%

Table 3. The expected risk-adjusted performance [7]

Expected							
Stock name	Average(Ri-Rf)	Standard deviation for (Ri-Rf)	Return for 2023	Risk for 2023	Beta	Sharpe ratio	Treynor Measure
ARQ	-0.01	0.20	0.05	0.26	0.89	-0.05	-0.01
CLWT	0.01	0.17	0.02	0.12	0.80	0.04	0.01
ERII	0.02	0.12	0.00	0.15	1.02	0.16	0.02
AVTR	0.01	0.11	0.01	0.11	1.03	0.08	0.01
DD	0.01	0.11	0.01	0.05	0.93	0.07	0.01
WLK	0.02	0.10	0.03	0.10	0.73	0.18	0.03
LYB	0.00	0.10	0.01	0.07	0.65	0.04	0.01

2.2.3. The actual performance of stocks (evaluation)

Table 4. A portfolio of stocks as of 30 April 2024

Stock	Current Price	Current-todate Dividend	Currentto-date Return	Current-todate Risk	Revised Expected Return	Revised Expected Risk
ARQ	7.76	None	1.72	37.97%	0.52	25%
CLWT	15.66	None	-0.1077	16.08%	0.05	10%
ERII	14.99	None	-0.2108	17.59%	0.21	17%
AVTR	24.23	None	0.0651	10.56%	0.15	15%
DD	72.5	0.38	-0.0646	15.25%	0.07	15%
WLK	147.36	0.50	0.047	12.23%	0.11	13%
LYB	99.97	1.25	0.0351	6.34%	0.10	10%
Nasdaq Index	15657.82	None	0.0604	4.39%	0.16	7%

2.2.4. The actual performance of portfolio (evaluation)

The current-to-date return of portfolio is 6.04% and current-to-date risk of portfolio is 4.39%. The portfolio's Sharpe ratio is 0.3948 and Treynor ratio is 0.049. Compared with benchmark and data of 2023 (Table 3), ARQ has an impressive performance. WLK, LYB and AVTR has a normal performance, and other stocks performed worse than benchmark and previous data.

2.2.5. The analysis of difference between prediction and evaluation

The prediction is worse than the evaluation. High inflation in the U.S. resulted in higher interest rates, which increased borrowing costs for businesses and decreased consumer spending, thereby putting pressure on stock valuations (Yiming. et al, 2024).

In the Pollution & Treatment Controls sector, companies like CLWT, and ERII have been adversely impacted by the broader economic slowdown. Reduced industrial activity and lower spending on pollution control initiatives have likely resulted in decreased revenues. Additionally, supply chain issues, such as disruptions in the supply of critical components or materials, have increased costs and caused delays, further straining these companies' performance (Yiming. et al, 2024).

In the Specialty Chemicals sector, firms such as DD has faced significant challenges due to rising inflation and interest rates. The higher costs of raw materials and increased interest expenses have squeezed their margins. Moreover, commodity price volatility has led to unpredictable earnings, complicating financial forecasting and stability. These companies are also contending with competitive pressures and market saturation, which have likely resulted in pricing pressures and reduced profitability (Yiming. et al, 2024).

3. CONCLUSION

With a 20% annual risk and a projected 20.5% return, the portfolio indicates high performance expectations. With a return of 6.72% and risk of 6.49%, the actual return and risk over the first four months, however, fell short of expectations. This suggests a notable early departure from expectations. Seven equities make up the portfolio: AVTR, DD, WLK, ARQ, CLWT, ERII, and LYB. To match performance to expectations and reduce risk moving ahead, adjustments can be required. Due to the impressive performance of ARQ, client should more focus on it.

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