The Empirical Research on Time-series Efficiency in Technology Industry, based on CAPM, Fama-French Three-Factor model, and Fama-French Five-Factor Model

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Abstract. Technical companies are renowned as stock market hotspots and are popular among investors. In light of the foregoing, this research uses excel solver to find the optimal portfolio by maximizing the Sharpe Ratio, then this research employs three widely used asset pricing models (CAPM, FF3F, and FF5F) and ten years data (2012/10/1-2022/9/30) to calculate the optimal expected return as the experimental group, moreover, this research uses four intervals data into three models to calculate the result of the contrast group to help investors making their decisions. This paper comes to a conclusion that the optimal portfolio expected return predicted by the CAPM with alpha is more accurate than the other models in short interval (1month, 2 months, 3 months, 6 months), whereas, FF5F performs better than the others in long interval(1 year). This paper's conclusion includes an investing strategy of technical enterprises for investors. Additionally, it also assists investors in allocating an optimal portfolio.

Keywords: Optimal Portfolio, CAPM, Fama-French Three-factor model, Fama-French Five-factor model

1 Introduction

Following a significant fluctuation of Tesla stock price, people has paid much attention on stock market, particularly the technology sector. Many people around the world have invested money in stock markets as a result of the complicated and developed stock markets that are found in an increasing number of nations. The development of all nations in the current world depends on technology, which has led to the rise in popularity of equities related to this sector. Because of this, financial models that forecast future stock returns are increasingly vital and well-liked. In this article, the study tries to test the time-intervals' efficiency of three main method (CAPM, FF3F, and FF5F) by optimal portfolio expected return. After the calculation, the study makes a comparison of four results by different intervals.

The research of model relation and test has always been a popular topic of academic world. The risk and the expected return are always the focus of investors, so what influence risk and expected return the most has become into a main research topic on asset pricing model and portfolio management nowadays. Moreover, factors research is becoming important these days,

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either. Melissa V et al. used Chinese stock market data from 1995 to 2008, and the result was market exposure, volatility, and leverage are not indicators of risk [1]. Qi-An C et al. made efforts on theoretical and empirical analyses based on the model, which showed equity premiums are low in prosperous times but high in difficult ones [2]. LIAMMUKDA A et al. used ADF test and a generalized additive model with a thin-plate spline to do the stationary test and estimate a coefficient of FF5F [3]. Haddad G et al. used the data listed on the SÃ£o Paulo and Shanghai stock exchanges, which showed liquidity influenced the expected returns significantly and negatively [4]. Omer C et al. used mathematical way drawn the conclusion as beta will always be important, regardless of how many more elements are included in the capital asset pricing model (CAPM) [5].

2. Data and method

2.1 Data collection

The research makes two groups by using the historical data of Microsoft, Oracle, Cisco, Apple, Amazon, Tesla, Netflix, Meta, Comcast, Vodafone, Verizon, and AT&T, which is from Yahoo Finance. The experimental group uses these twelve companies' data from 2012/10/1 to 2022/9/30 into three different methods (CAPM, FF3F, FF5F) to calculate the expected returns, and the contrast group uses these twelve corporations' data (2022/10/1-2022/10/31, 2022/10/1-2022/11/30, 2022/10/1-2022/12/31, 2022/10/1-2023/3/31, and 2022/10/1-2023/9/30) into three different methods to calculate the expected returns with the aim of making a comparison with experimental group. Meanwhile, the research also uses the data of SPY from Yahoo Finance, and the data in FF3F and FF5F calculations is from Kenneth R. French website.

2.2 Method: CAPM

Based on [6], the CAPM is a development of former mean variance analysis. It claims that the price of an asset is determined by its contribution to the risk of a tangency portfolio. Furthermore, it's the first asset pricing model by considering the market as a factor. Additionally, people are eager to optimize their equities, so it is the market portfolio, either. Then the author shows the CAPM equation:

$$E(r_i) = r_f + \beta_i E(r_m - r_f) \tag{1}$$

$$E(r_i) = r_f + \beta_i E\left(r_m - r_f\right) + \alpha \tag{2}$$

where $E(r_i)$ stands for the expected return of asset I, r_f stands for the risky-free rate, $E(r_m - r_f)$ stands for the equity risk premium, as known as the excess expected return, β_i stands for the price fluctuation of asset i relative to the stock market, α stands for its deviation from the prediction.

2.3 Method: FF3F

Based on [7], the FF3F is a more accurate and sophisticated model than the CAPM. To capture the anticipated return, it encourages the use of multiple factor models. The FF3F adds two new

factors into the equation: size and value. Nevertheless, it is also a milestone of asset pricing as the beginning of factors model. The equation of this model is:

$$r_i - r_f = a + b(r_m - r_f) + s(SMB) + h(HML) + e_i \quad (3)$$

where b, s, and h are coefficient in this equation, SMB is the difference between the returns on portfolios of small capital and large capital, HML is high B/M portfolio expected return minus low B/M portfolio expected return, and e_i is a zero-mean residual.

2.4 Method: FF5F

Based on [8], the FF5F performs better than FF3F. It adds two more factors (RMW and CMA) than FF3F into the equation to make the prediction for the expected return closer the real return in stock market. The two new factors make FF5F is capable to reflect a more accurate situation of a company or a portfolio than FF3F. The equation is:

$$r_i - r_f = a + b(r_m - r_f) + s(SMB) + h(HML) + r(RMW) + c(CMA) + e_i \quad (4)$$

where r and c are coefficients of new factors, RMW is the difference between the returns on portfolios of stocks with robust and weak profitability, CMA is the difference between the returns on diversified portfolios of the stocks of low and high investment firms.

3. Result

3.1 CAPM with and without alpha

This study uses CAPM with and without alpha to calculate the optimal portfolio expected returns: Firstly, the study uses Yahoo Finance to find the data and calculate SPY return, then the study sets 0.001 as risk-free return to find the excess returns of twelve companies. Secondly, the study runs the average function in excel by using SPY return into it, furthermore, the study uses regression from data analysis to figure out the betas and alphas of twelve stocks. Thirdly, the study uses CAPM formula to find out the expected returns. Finally, the study uses solver to figure out the optimal portfolio, and its expected return. The results show in table 1, table 2, and table 3 first two columns

3.2 FF3F and FF5F

The research employes FF3F and FF5F to determine the expected return: First step, the research calculates the parameters using data from the website of Kenneth R. French, then, the research utilizes data analysis to determine the coefficients of these parameters. Additionally, SUMPRODUCT function is used to determine the expected returns. Third step, the study uses solver to determine the optimal portfolio and its expected return. The results show in table 1, table 2, and table 3 last two columns

Table1: weight result

Returns for portfolios	CAPM without alpha	CAPM with alpha	FF3F	FF5F
MSFT	0.110209897	0.458033479	0.057320923	0
ORCL	0.19678094	0	0.220244723	0.153151834
CSCO	0.083318644	0.00551224	0.103064541	0.067436944
AAPL	0.086029926	0.096709184	0	0.126827649
AMZN	0.104765088	0	0.029342491	0
TSLA	0.024694879	0.137849848	0.033940822	0.007990043
NFLX	0.016748586	0.141085663	0.009716466	0
META	0.027133311	0.010873158	0.011601688	0
CMCSA	0.146422222	0	0.122766563	0
VOD	0.077828656	0	0.099375708	0.019175396
VZ	0	0	0	0.140923499
AT&T	0.126067844	0.149936396	0.312626076	0.484494648

Table 2: return result

Return	CAPM without alpha	CAPM with alpha	FF3F	FF5F
1 month	0.0684	0.0358	0.1133	0.1306
2 months	0.1291	0.0795	0.1837	0.1825
3 months	0.0612	-0.0174	0.1230	0.1301
6 months	0.2300	0.1968	0.2578	0.2374
1 year	0.3375	0.2706	0.2835	0.1430

Table 3: return difference

Difference (absolute value)	CAPM without alpha	CAPM with alpha	FF3F	FF5F
1 month	0.0576	0.0102	0.1048	0.1202
2 months	0.1183	0.0539	0.1752	0.1721
3 months	0.0504	0.0430	0.1145	0.1197
6 months	0.2192	0.1712	0.2493	0.2269
1 year	0.3267	0.2450	0.2750	0.1325

3.3 Comparison

On the one hand, the CAPM with alpha optimal portfolio expected return has the lowest absolute value in 1 month, 2 months, 3 months, and 6 months, which means the CAPM with alpha is the best method to predict expected return in optimal portfolio. Meanwhile, the FF5F optimal portfolio expected return has the lowest difference in 1 year, which means the FF5F is the best method to foresee optimal expected return. It's worth to noticing that Fama-French Factors model isn't the best method to price the asset portfolio in month, 2 months, 3 months, and 6 months, though FF3F and FF5F have considered more factors than CAPM. Moreover, it's interested that CAPM with and without alpha have similar difference in 3 months. On the other hand, FF5F has the lowest difference in 1 year, which shows it has the best performance. Lastly, CAPM without alpha and FF3F may not be useful in asset pricing anymore, because they do not perform well anyway.

4 Discussion

After a comprehensive observation of the charts again, this study pays attention to the parameter alpha, which play an important role in CAPM. As the CAPM without alpha has a big absolute value as well as FF3F and FF5F in first four intervals, meanwhile, CAPM with alpha performs better than the others in first four intervals. It shows the importance of alpha in first four intervals.

Nevertheless, the FF5F does perform better than the other models after the interval becomes into a year, which means that FF5F may not be useful in a short time, but it's useful if the interval is a year.

Although model formula is more important than time period, the research uses ten years data to predict at most next year optimal portfolio expected return seems not fair enough. For improvement, the research may make two groups have the same time period, which can acquire a more precise result.

5 Conclusion

This study uses ten years data into CAPM, FF3F, and FF5F to observe and analyze different intervals optimal portfolio expected returns in technology industry, and makes a comparison of them. The conclusion is the CAPM with alpha is more precise when the contrast group's time interval is less than a year, whereas FF5F performs the best in these methods when the contrast group's time period is equal or more than a year, furthermore, CAPM without alpha and FF3F do not predict well in short and long periods.

This paper offers advice to those who are keen to purchase equities in the technology sector. Additionally, because the article compared three widely used portfolio management models, it offers a wealth of information to those investors. Also, it gives a list of the stocks in the technology sector.

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