Comparison of CAPM And Fama-French Three-factor Model

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Abstract. Asset pricing is very important for financial market operation. The capital Asset Pricing Model and Fama-French three-factor model are two classical asset pricing models. This essay, compared portfolio returns and utility under different model settings by constructing a portfolio, conclude that the Fama-French three factor model is more effective than the CAPM model. It can more comprehensively include factors affecting stock prices to project the price in the future. In our study, we found drawbacks in the assumptions of the CAPM model, the assumptions give the model a perfect market which is far away from the fact. However, Fama-French three factor model also has its downsides. We just talk about the better choice between the two models. After the research, there still exist some limitations to our study. We need to conduct in-depth research to refine asset pricing models.

Keywords: CAPM model, Fama-French three-factor model, asset pricing.

1. Introduction

In terms of asset pricing, we have many models that include different factors to calculate the predicted price, such as CAPM model, Fama-French three-factor model, and the Multi-factor model. These models have equal status in the area of asset pricing. CAPM model is widely used in applications, such as estimating the cost of capital for companies that manufacture or perform an appraisal of financial instrument portfolios.[1] However, in practice, which model is more efficient or which expected return is the most approach to the actual price, these concerns need us to argue.

This article is divided into 5 parts. The first one is the introduction, in this part, we briefly talk about the background of asset pricing, and the structure of this essay. In the second part, introduce the basic information of the four assets we choose, totally about the type of assets, the price volatility with time, and historical data like 5 years returns. The third session mentions the model we talk about: CAPM model and Fama-French three factor model. Mainly about the assumption of two models, and the factors that they conclude in the model. Forth part shows the result of the calculation of two models and compares the portfolio with and without risk-free assets by maximizing the sharp ratio. The final part gives a summary of the whole essay, which contains the method we use in the study, the conclusion, and the shortage of the research.

2. Data

The data we use contains two medical companies, one “Innovation” ETF and one small-cap value mutual fund from May 1st,2017 to Juan 1st,2022 monthly price.

The theme of ARKK is 'innovation'. They believe that when revolution is around the corner, some technology equities will lead the change in markets. Also, ARKK is an active ETF, which means the team can adjust the positions and run risk management at any time. The 5 years return of ARKK hit 175.50% with a variance of 0.0108, relatively low compared to the high growth rate. The top holdings of this ETF are some thriving companies in the field of electric vehicles and internet giants, which are mainly growth-oriented stocks. The stock price changes in 5 years are shown in Fig 1.

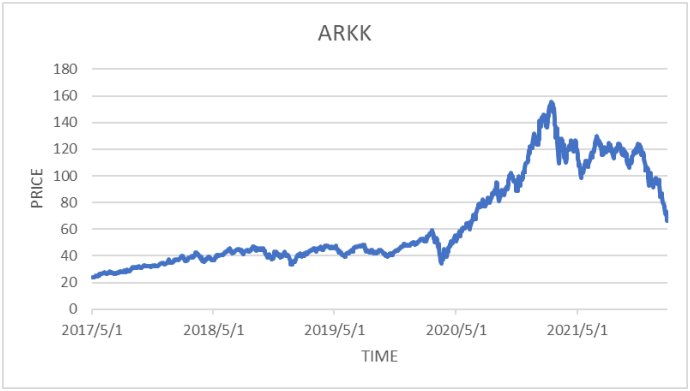

Figure 1:ARKK's price movement over time

BRSVX is the best-performing mutual fund of 2021. This fund focused on small-cap equities and this strategy has paid off well in the historic economic recovery. Over a 10-year period, the fund achieved an annualized total return of 14.8%, 2 percentage points higher than the Russell 2000 Value Index, according to Morningstar. The main area of its top holdings in financial services. According to their Book to Market Ratio, most stocks are value-oriented. The stock price changes in 5 years are shown in Fig 2

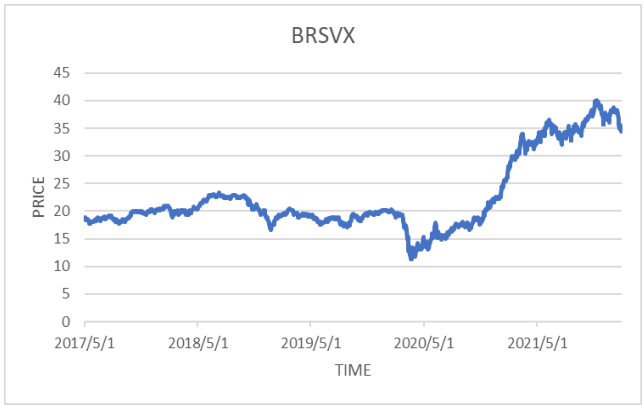

Figure 2:BRSVX's price movement over time

During the pandemic, healthcare stock is a popular choice. We predict that the market size of medical devices will continue to expand. Therefore, two medical companies are included in the portfolio to add to the stock proportion as well as bring potential high growth. As shown in the Fig 3 and Fig 4, both of them are competitive in the area.

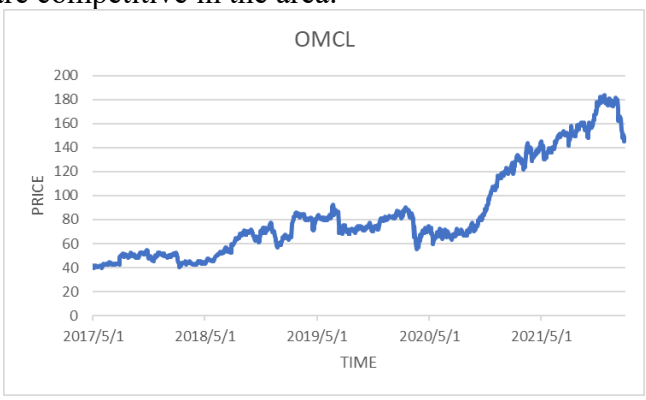

Figure 3: OMCL's price movement over time

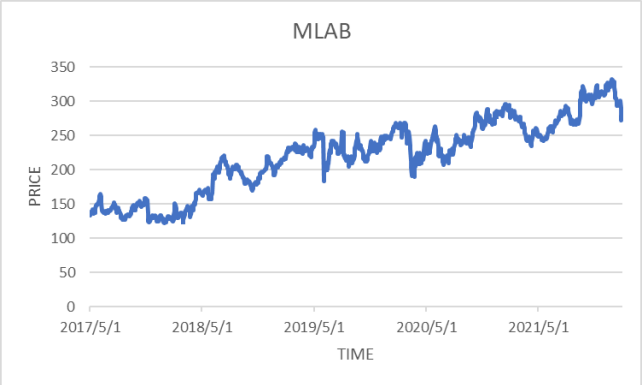

Figure 4: MLAB's price movement over time

The four choices include big cap, small cap, growth, and value-oriented stocks and cover a variety of areas. In Markowitz's Portfolio Theory, the lower the correlation of the returns, the lower the risk of the portfolio. We use excel test 4 assets correlation, and the result indicates that it is a low-risk portfolio. In that case, all of them could be included.

3. Research Methods

3.1 CAPM model

Capital Asset Pricing Model(CAPM) was set up by William Sharpe, John Lintner, Jack Treynor, Jan Mossin in 1964, based on Asset Portfolio Theory and Capital Market Theory. Assumptions of CAPM are established on Markowitz Asset Selection Theory Model. It concludes that:1. All investors can borrow or lend funds at risk-free rates without restrictions2. All investors seek to maximize the expected utility of their wealth in a single period and base their portfolio selection on the expected return and standard deviation of each alternative portfolio3. The market has full liquidity and no transaction costs, and all assets can be fully segmented4. All investors are price takers, which means the buying and selling behavior of anyone investor does not have an impact on the stock price5. The total quantity of assets is fixed. The CAPM model makes a number of simplifying assumptions, of which the most relevant to this note are about investor behavior and the presence of a single common risk factor[2]. Based on these assumptions, introduce in β get CAPM model:

$$\mathrm{E}(r_i) = r_f + \beta_{im}(E(r_m) - r_f) \cdots\cdots \quad \cdots\cdots (1)$$

E_{r_i} is the expected return of the asset. . r_f refers to the risk-free rate, β_{im} presents factor of non-diversifiable risk, $E(r_m)$ is the expected return of the market portfolio.

As for CAPM model, it combines risk-free rate and risk price together to price assets, can reflect to some extent to forecast asset prices in the market. However, the price of an asset mostly depends on the β[3], and this factor merely indicates the trend in the past. When we forecast the future tendency, as a single risk factor, it is not a typical data that perfectly predicts price in the following years[4]. Apparently, CAPM model has numerous assumptions and provides us with a relatively perfect scenario, which is different from the fact.

3.2 Fama-French three factor model

In 1992, Fama and French's study of the factors that determine the differences in returns of different stocks in the U.S. stock market found that the beta of the stock market does not explain the differences in returns of different stocks, while the market capitalization, book-to-market ratio, and price-to-earnings ratio of listed companies explain the differences in stock returns[5]. In their research, stock market value and book-to-market value can explain mostly the volatility of the stock price. In 1993, they put forward a three-factor model to explain the stock return. The equilibrium pricing model can be expressed as:

$$\mathrm{E}(R_{it}) = R_{ft} + \beta_i\left[E\left(R_{mt} - R_{ft}\right)\right] + s_i SMB_t + h_i HML_t \cdots\cdots (2)$$

β_i, $s_i$and $h_i$present the coefficient of each factor. E(R_{it}) is the expected return of the asset. R_{ft} refers to the risk free rate. SMB_t is market value factor, HML_t is book-to-market ratio factor.

Fama-French three factor model is a development of asset pricing models, it adopted totally different methods and factors to explain the expected return. Applying Fama-French three factor model, we can by using specific factors to calculate the return of assets gets a more precise forecast. Although Fama French has tried to overcome the drawbacks of the CAPM. Their original three-factor model also possesses some limitations as well.[6]

4. Result

Use the CAPM model, to calculate the two portfolios: with the risk-free rate and without the risk-free rate. Each portfolio we choose maximizes the sharp ratio to get an optimal portfolio.

4.1 CAPM model

We first use CAPM model to calculate the expected returns. Just use SPY index to represent market return and subtract the risk-free rate from the returns to figure out the market excess return. Next, by running the market excess return and stock excess return regression model without alpha. Then use the formula(1) to calculate the expected return, standard deviation, and sharp ratio. Finally, use the tool called "SOLVER" in excel to get the largest sharp ratio and corresponding expected return. Table 1 shows the result of the calculation.

Table 1:Portfolio without risk-free assets under CAPM model

	ARKK	BRSVX	MLAB	OMCL
WEIGHT	0.221896	0	0.297992	0.480112
Expected return	0.025264		Sharp ratio	0.350607

After work out the portfolio of four assets, we add risk-free asset into the portfolio and just repeat the steps above. We will have new weights between these assets, as shown in Table 2.

Table 2:Portfolio of assets with risk-free assets under CAPM model

	ARKK	BRSVX	MLAB	OMCL	Risk-free
WEIGHT	0.000188	0.0023	0	0.001525	0.995988
Expected return	0.00096		Sharp ratio	1.291428	

4.2 Fama-French three factor model

Fama-French three-factor model is used to calculate the expected returns. First, lining up monthly market factors' returns from Fama French in their decimalized format with the four returns. Subtracting risk-free rate from the returns, excess return is calculated. Next, by running the three-factor regression model of expected excess return without alpha. Then use the formula(2) to calculate the expected return, standard deviation, and sharp ratio. Finally, use the tool called "SOLVER" in excel to get the largest sharp ratio and corresponding expected return. Table 3 shows the result of the calculation.

Table 3:Portfolio without risk-free assets under Fama-French three factor model

	ARKK	BRSVX	MLAB	OMCL
WEIGHT	0.048345	0.684885	0.123563	0.143207
Expected return	0.012636		Sharp ratio	0.169269

After working out the portfolio of four assets, we add risk-free assets into the portfolio and just repeat the steps above. We will have new weights between these assets, as shown in Table 4.

Table 4:Portfolio with risk-free assets under Fama-French three-factor model

	ARKK	BRSVX	MLAB	OMCL	Risk-free
WEIGHT	0	0.003094	0	0.000116	0.99679
Expected return	0.00092		Sharp ratio	1.264537	

4.3 Comparison

Compared to the two model outcomes, the expected return and sharp ratio we calculate, obviously that CAPM is lower than Fama-French three factor model. The reason that leads to the result, is that when calculating CAPM expected return, the market risk premium is considered only, leading to market portfolio returns being the only factor affecting the sensitivity. But when calculating FF3F expected return, the loadings on SMB and HML are also considered, that is, the factors, size, and value are all taken into effect. Size and value risk premiums matter very much. Only using the market risk premium is not enough at all since expected returns are affected by multiple risk factors in real life. In the real world, this assumption clearly has a weakness, because no one proxy is sufficient to describe why the return of stock changes.[7]Therefore, CAPM model has many limitations and FF3F model has better investment guidance.

5. Conclusion

In the study, we based on the CAPM model and Fama-French three-factor model to compare which pricing model is more stable for the market trend. Generally, we set up portfolios to calculate the expected return in a different situation, and use the sharp ratio as metric.

After the comparison, we found that obviously the expected return and sharp ratio of CAPM are both lower than those of Fama-French three factor model. Based on the data we worked out, we can give a basic conclusion—Fama-French three factor model has better investment guidance when we set up a market portfolio. The reason why is that, Fama-French three factor model contains more influencing factors, it is stronger and more comprehensive to explain the pricing.

Besides, looking back on our research, it is not difficult to find that there still exist some problems. Our study was only based on 5 years of historical data, it seems that a small part of the stock price volatility, can not strongly prove which model is more efficient. Also, in the study, we give an implicit assumption that in the future the market will not change, everything is fixed, and only models are variables. However, the world is changeable, we can not predict the uncertainty of the future. Thus, the study can not show how much the two models can contain the unpredictable risk, and how efficient when we use them in the actual market. These weaknesses need us to continue our research and have a powerful conclusion.

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