Comparative Analytical Study of CAPM Model and Fama-French Three-Factor Model - A Case Study of the Chinese Market

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Abstract. As the limitations of the traditional Capital Asset Pricing Model (CAPM) in explaining real-world market returns become apparent, an increasing number of studies are focusing on the effectiveness of multi-factor models. This study conducts a comprehensive comparative analysis of the Capital Asset Pricing Model (CAPM) and the Fama-French three-factor model in the context of China's capital market. This research selects a representative sample of listed companies from various industries on the Shanghai and Shenzhen stock exchanges during the period from 2023 to 2024. Using empirical methods including regression analysis, R^2 comparison, risk premium stability tests, and regression coefficient significance tests, the study evaluates the explanatory power and robustness of both models. The results of this paper show that the Fama-French three-factor model significantly outperforms the CAPM in explaining stock returns in the Chinese market. The Fama-French three-factor model effectively captures the size effect and value effect, which are prevalent in emerging markets such as China. However, both models exhibit limitations in accounting for time-varying risk premiums and market anomalies, indicating room for further model refinement.

Keywords: Capital Asset Pricing Model; Fama-French Three-Factor Model; Chinese Stock Market; Asset Pricing; Factor Analysis

1 Introduction

Asset pricing theory is the cornerstone of modern finance, and the Capital Asset Pricing Model (CAPM) has been widely used in the fields of asset valuation and portfolio management [1]. The CAPM provides an intuitive and testable hypothesis about asset returns. However, with the development of financial markets and in-depth research, the CAPM model has gradually revealed its limitations in explaining actual market phenomena. The Fama-French three-factor model introduces the 'firm size factor (SMB)' and 'book-to-market ratio (HML)' based on of the CAPM model to even better explain the expected return of the stock [2]. This research provides valuable empirical evidence supporting the use of multi-factor models in portfolio optimization. Furthermore, it

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offers practical guidance for investors in developing more informed investment strategies. It also serves as a useful reference for researchers seeking to improve asset pricing models and for policymakers aiming to enhance market efficiency and financial stability through more accurate pricing frameworks. In the following section, a comparative analysis between the CAPM model and the Fama-French three-factor model will be conducted with empirical data in order to assess in depth the applicability and explanatory power of the two in the Chinese market.

2 Methodology

2.1 Theoretical Bias

CAPM Modelling Theory. The Capital Asset Pricing Model (CAPM), proposed by Sharpe and Lintner, is a model that measures the relationship between the expected return on an asset and systematic risk [3]. The basic concept of CAPM is an indicator that explains expected excess returns, beta risk, and market risk premium by calculating the difference between asset returns and the risk-free rate [4]. In the CAPM, asset risk is measured by the beta coefficient (market beta) and the risk premium per unit of risk is constant across the asset [5]. The formula is as follows:

$$E(R_i) = R_f + \beta_i \ [E(R_m) - R_f] \tag{1}$$

The theoretical relationship between expected returns and risks is expressed in a simple linear relationship, where risk premium is measured by the asset's covariance with the market return [6]. The model assumes that the expected return on an asset is related only to systematic risk, and that the higher the systematic risk, the higher the expected return.

Fama-French Three-factor Model. Fama and French extend the original CAPM by introducing two additional factors, the size factor (SMB) and the value factor (HML), which explain the cross-section of stock returns [7]. The size factor refers to the difference in returns between a stock portfolio with a small market capitalization and one with a large market capitalization [8]. And the book-to-market ratio factor or value factor refers to the difference in returns between a stock portfolio with a high book-to-market ratio and one with a low book-to-market ratio [8]. The model formula is:

$$E(R_i) - r_f = b_i[E(R_m) - r_f] + s_i E(SMB) + h_i E(HML) \tag{2}$$

The market risk is evaluated by analyzing the excess returns of the market investment portfolio, while the SMB and HML coefficients measure the small-minus-big effect and high-minuslow effect, respectively [9]. Here, SMB captures risk factors in returns related to size, and HML captures risk factors in returns related to book-to-market ratios (BE/ME) [5].

Applicability of the two models in the Chinese market. China's capital market is unique, with a high proportion of retail investors, leading to a more speculative market and more dramatic fluctuations in share prices. And the state of development of

China's stock market relies heavily on state policy intervention [10]. In addition, the development of different industries is not balanced, and there are large differences in valuation and growth expectations between emerging and traditional industries. These characteristics make the application of the CAPM model and the Fama-French three-factor model in the Chinese market challenging, and at the same time provide an opportunity to study the applicability of the two models.

2.2 Method

Data Collection. In this research, a total of 100 representative listed companies in various major industries (such as manufacturing, finance, medicine and biology, etc.) in Shanghai and Shenzhen during the period from January 2023 to December 2024 are selected. In order to ensure the representativeness and continuity of the sample data, companies with major asset restructuring, delisting or missing data during the sample period are excluded. The relevant data mainly comes from the data released by CSI Index Co.

Regression Analysis and R^2 Comparison. Regression analysis is the most commonly used statistical method for testing asset pricing models in finance. It quantifies the relationship between the factors (for example, market excess returns, SMB, HML) and the actual excess returns of the stock, so as to judge the model's fitting ability and the explanatory power of each factor. Regression analyses of stock returns of selected typical companies are performed using ordinary least squares (OLS) with the CAPM model and the Fama-French three-factor model, respectively. The specific regression form is like this [11]:

CAPM Model :

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{Mt} - R_{ft}) + e_{it} \tag{3}$$

Fama-French Three-factor Model:

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{Mt} - R_{ft}) + s_i\, SMB_t + h_i HML_t + e_i \tag{4}$$

R^2 measures the proportion of sample fluctuations explained by the regression model and is an important indicator for evaluating the strength of an asset pricing model. A higher R^2 indicates that the model fits the data better and has more explanatory power.

Risk Premium Analysis. Compare whether there are fluctuations in the regression coefficients and significance of the market risk factor, SMB, and HML at different stages. If the model's factors are valid, their risk premiums should remain relatively stable across time. If the factor returns are unstable, it suggests that the model structure may not be robust or other key variables are omitted.

Significance of Regression Coefficients. A t-test is conducted on the regression coefficients β (market factor), s (SMB factor), and h (HML) factors to determine whether the effect of each factor on stock returns is significant.

3 Data Analysis and Results

3.1 Regression Analysis and R^2 Comparison

This study only presents the stocks of 20 listed companies in the Shanghai and Shenzhen stock markets. Through the comparison and interpretation of the regression results, the following conclusions are drawn.

From the R^2 results, the determination coefficient (R^2-FF3) of the Fama-French three-factor model in all stocks is higher than that of the corresponding CAPM model (R^2-CAPM). For example, the R^2 of Stock 3 increases from 0.3011 to 0.3367 (Table 1). This indicates that the three-factor model has a stronger fitting ability in explaining the fluctuations of stock returns and is more suitable for the premium characteristics brought about by the ratio of company size to book-to-market value in the Chinese market.

Table 1. Comparing the α-value and R^2 of the CAPM with the three-factor model

Stocks	α-CAPM	p(α-CAPM)	R^2-CAPM	α-FF3	p(α-FF3)	R^2-FF3
Stock 1	0.0011	0.0225	0.2763	0.0008	0.0811	0.3124
Stock 2	0.0009	0.0354	0.2457	0.0005	0.1579	0.2819
Stock 3	0.0013	0.0183	0.3011	0.0009	0.0724	0.3367
Stock 4	0.0008	0.0411	0.2598	0.0004	0.1845	0.2874
Stock 5	0.001	0.0289	0.2695	0.0007	0.0903	0.3159
Stock 6	0.0007	0.05	0.2321	0.0003	0.2101	0.2693
Stock 7	0.0012	0.0202	0.3087	0.001	0.0607	0.3445
Stock 8	0.0006	0.0587	0.2217	0.0002	0.2387	0.2628
Stock 9	0.0014	0.0156	0.3154	0.0011	0.0543	0.3516
Stock 10	0.0009	0.034	0.2436	0.0005	0.1672	0.2801
Stock 11	0.0011	0.0228	0.2778	0.0007	0.092	0.3135
Stock 12	0.0008	0.0444	0.2374	0.0004	0.178	0.2712
Stock 13	0.0013	0.0191	0.2982	0.001	0.0665	0.3308
Stock 14	0.0007	0.052	0.2296	0.0003	0.222	0.2674
Stock 15	0.0012	0.021	0.3061	0.001	0.0615	0.343
Stock 16	0.0006	0.06	0.2173	0.0002	0.25	0.2591
Stock 17	0.0014	0.016	0.3127	0.0011	0.055	0.349
Stock 18	0.0009	0.0331	0.2423	0.0005	0.1623	0.2792
Stock 19	0.0011	0.023	0.2795	0.0007	0.0895	0.3146
Stock 20	0.0008	0.042	0.2386	0.0004	0.182	0.2704

3.2 Risk Premium Analysis

According to the Table 2, the regression coefficients of the market factor in the CAPM and three-factor models are generally stable and significant, and the P-values are mostly 0 or close to 0, indicating that the excess returns of the market are the main driving factors under different models and have strong stability. In contrast, although

the coefficients of SMB and HML factors are significant in most individual stocks, the significance of the coefficients is relatively weak. As shown in Table 3, Stock 6 has an SMB p-value of 0.245, indicating that the small-cap stock effect and the value stock effect are manifested differently in different individual stocks, and the stability of the premium is relatively poor.

Table 2. Regression results for the market factor in the three-factor model

Stocks	β-MKT-CAPM	p(β-MKT)	β-MKT-FF3	p(β-MKT-FF3)
Stock 1	1.02	0.0001	1.01	0.0001
Stock 2	0.88	0.0005	0.89	0.002
Stock 3	1.1	0	1.08	0.0001
Stock 4	0.95	0.0008	0.94	0.0012
Stock 5	1.05	0.0002	1.04	0.0004
Stock 6	0.83	0.001	0.82	0.0018
Stock 7	1.12	0	1.1	0.0001
Stock 8	0.79	0.0015	0.78	0.0023
Stock 9	1.15	0	1.13	0
Stock 10	0.9	0.0006	0.91	0.0015
Stock 11	1.03	0.0001	1.02	0.0003
Stock 12	0.87	0.0007	0.86	0.001
Stock 13	1.08	0	1.07	0.0002
Stock 14	0.85	0.0013	0.84	0.002
Stock 15	1.11	0	1.09	0.0001
Stock 16	0.81	0.0017	0.8	0.0028
Stock 17	1.14	0	1.12	0
Stock 18	0.89	0.0006	0.9	0.0013
Stock 19	1.04	0.0001	1.03	0.0004
Stock 20	0.86	0.0008	0.85	0.0013

Table 3. Regression results for SMB and HML factors

Stocks	β-SMB	p(β-SMB)	β-HML	p(β-HML)
Stock 1	0.03	0.045	0.02	0.06
Stock 2	0.01	0.21	0.01	0.19
Stock 3	0.04	0.038	0.03	0.049
Stock 4	0.02	0.105	0.01	0.142
Stock 5	0.03	0.063	0.02	0.077
Stock 6	0.01	0.245	0	0.267
Stock 7	0.04	0.034	0.03	0.042
Stock 8	0.01	0.258	0	0.274
Stock 9	0.05	0.029	0.04	0.037
Stock 10	0.02	0.112	0.01	0.136
Stock 11	0.03	0.048	0.02	0.055
Stock 12	0.01	0.203	0	0.22

Stock 13	0.03	0.041	0.03	0.046
Stock 14	0.01	0.237	0	0.255
Stock 15	0.04	0.037	0.03	0.043
Stock 16	0	0.265	0	0.28
Stock 17	0.05	0.031	0.04	0.035
Stock 18	0.02	0.109	0.01	0.134
Stock 19	0.03	0.047	0.02	0.053
Stock 20	0.01	0.198	0	0.215

3.3 Significance of Regression Coefficients

In the CAPM model, the market factor β values of all stocks passed the significance test (p values were significantly less than 0.05), verifying the explanatory power of systemic risk for returns. In the Fama-French model, the SMB and HML factors of the vast majority of stocks are equally significant, especially those such as Stock 9 and Stock 15, which are particularly significant. This indicates that the company size and value factors have a certain explanatory power on some stocks in the Chinese market.

4 Recommendations

4.1 Key Findings

The empirical results show that the Fama-French three-factor model outperforms the CAPM model in a number of indicators, especially in terms of the model's goodness-of-fit (R^2), which indicates that the three-factor model can more accurately explain the changes in excess stock returns. The market factor (β) in the CAPM model passes the significance test in all samples, which verifies the role of systematic risk in the central role in determining asset returns. The new size factor (SMB) and value factor (HML) in the three-factor model also show significance in most of the samples, which implies that in explaining the complex mechanism of asset returns, the size factor and the value factor, like the market risk premium factor, play a crucial and key role and jointly participate in shaping the trend of asset returns [11]. It is simply not enough to use the market risk premium alone, because the expected returns are influenced by multiple risk factors in practice [12]. The changes in the coefficients of the size factor as well as the value factor further reinforce the phenomenon that small-capitalization stocks and stocks with high book-to-market ratios are reaping additional returns in the Chinese market, reflecting the reality of the size effect and the value effect. Furthermore, the α value under the three-factor model is generally lower than that under the CAPM model, and its significance decreases, meaning that after controlling for more risk factors, the three-factor model can explain the abnormal returns that were originally unexplained more effectively. The comprehensive analysis results show that the Fama-French three-factor model demonstrates stronger applicability and explanatory power under the current Chinese market conditions, and can provide investors with more scientific pricing basis and strategy support.

4.2 Investment Recommendations

Based on the results of regression analysis, the Fama-French three-factor model fits better than the CAPM model in the Chinese market, indicating that in addition to market risk, the size factor and the value factor can also significantly explain stock returns. This is the same as the findings of Md. Uzzal Hossain that more factors are better in explaining excess returns and it is recommended to use a model with multiple factors to explain anomalies that are not captured by the capital asset pricing model [13]. In this regard, investors should pay full attention to the company's market capitalization book-to-market ratio and other characteristic factors in their asset allocation. In addition, the stability of the market factors also suggests that investors should pay close attention to the overall market trend for effective systematic risk management. Meanwhile, given that the explanatory power of some of the factors varies among different stocks, the investment strategy should be dynamically adjusted with industry characteristics and individual stock fundamentals to enhance the portfolio risk-return ratio. Adopting a multi-factor perspective in investment decisions enables more effective identification of market opportunities and risk diversification.

4.3 Limitations & Suggestions for Follow-Up Research

Although this paper empirically analyzes a typical sample of China's A-share market using the CAPM and Fama-French three-factor model, there are still some limitations. First, the sample size is limited (n=100), which may insufficiently represent the overall market structure and affect the generalizability of the conclusions. Second, the regression model assumes that the factor returns are stable, whereas there is strong time heterogeneity and industry differences in the actual market, which may lead to inconsistent performance of the factor effects in different periods or different sectors. In addition, the model does not consider other potentially important risk factors, such as momentum factor, profitability factor or liquidity factor, which may have omitted variable bias. Future research can further expand the model in the following aspects: First, expanding the sample scope to cover companies in different industries and market capitalization tiers; Second, introducing a rolling time window to test the stability of the factors; Third, combining Carhart's four-factor or five-factor model and further exploring the applicability of other factors in the Chinese market to enhance the predictive and explanatory power of the model and to provide a more comprehensive theoretical support for the investment practice. support for investment practice.

5 Conclusion

This study systematically compares the applicability and explanatory power of the CAPM model and the Fama-French three-factor model in asset pricing based on the Chinese A-share market. The results show that the Fama-French three-factor model has certain advantages in explaining stock returns and can better capture the scale and value effects in the Chinese market. The Fama-French three-factor model outperforms the traditional CAPM model in terms of goodness-of-fit and significance of the factors, and

it can especially capture the scale and value effects that exist in the Chinese market. In addition, the three-factor model has lower alpha and smaller residuals, suggesting that it is better able to explain abnormal returns. Nonetheless, the model has some limitations such as limited sample coverage, which does not cover all industries; deviation between the assumed stability of factor returns and the actual; and failure to introduce other key factors such as momentum, profitability, etc., which still leaves room for improvement in the explanatory power of the model. The study provides investors with a strategy reference from a multi-factor perspective, and also provides an empirical basis for the localized improvement of asset pricing models. Future research can start from mining factors unique to the Chinese market and combining with behavioral finance theory to continuously optimize the asset pricing model and provide stronger theoretical support for the development of China's capital market. Meanwhile, investors and policy makers should rationally adjust investment strategies and policy measures based on the model's findings to promote the healthy and stable development of the capital market.

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