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The Performance of Fama-French Asset Pricing Models in the Chinese Stock Market

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Abstract: Three prominent models are used in finance to forecast stock returns and evaluate asset pricing: the Capital Asset Pricing Model (CAPM), the Fama-French three-factor model (FF3), and the Fama-French five-factor model (FF5). The Chinese stock market exhibits unique characteristics and is subject to distinct policies compared to U.S. and European markets. Within the framework of the Chinese Shanghai A-share market, this paper aims to analyze the precision of the forecast of these traditional models for stock market yields. The study utilizes daily stock market data spanning from January 4, 1994, to December 25, 2023, focusing on the Shanghai A-share market while excluding the Growth Enterprise Market (GEM) and the Key Economic Market (KEM). By examining the predictive power of various factors associated with excess returns or risk premiums, the purpose of the article is to assess these models' resilience in the context of the Chinese stock market. The results of the empirical analysis demonstrate that the three-factor model fits the dataset better than the five-factor model or the traditional CAPM in the Chinese market.

1. Introduction

In finance, asset pricing has consistently been an increasingly prevalent subject. The FF3 model is one of the most prominent asset pricing models, right behind the CAPM. FF5 model was created in 2015 as an expansion of the FF3 model. The FF3 model gains the profitability component and the investment pattern element from the FF5 model. The growth of the asset pricing sector has been significantly influenced by this improvement, which is extensively employed in the fields of finance, economics, and other research endeavours [1].

Upon its initial proposal, the CAPM model was widely acknowledged as the preeminent model in the asset pricing domain and as the most effective means of elucidating the correlation between capital market return and investor risk [2]. The model's construction was based on the assumptions that investors would behave rationally and that the relationship between the risk-free rate and the total risk of the asset and the market would be linear in determining the expected return on an asset [3]. However, starting in the 1970s, scholars began to gradually recognize that the CAPM model had a number of limitations and needed help to adequately explain a wide range of phenomena occurring in the market.

Several significant studies discovered that investing in stocks based on a specific investing style—

such as small-capitalization businesses or low P/E ratios—could, in the long run, produce returns that exceed market averages. This event prompted the creation of more complex asset pricing models and cast doubt on the applicability of the CAPM model [4]. Scholars have come to realize that the CAPM fails to comprehensively account for the multiple risk factors present in the market, and therefore more factors need to be introduced to more accurately elucidate the variations in returns among categories of assets.

The presentation of FF3 marks the extension and evolution of CAPM [5]. The market capitalization factor and the book-to-market ratio factor, two additional risk factors that increase the model's complexity but also give it a more thorough explanatory capacity, are its essential components [6]. One of the primary attributes of the FF3 model is the market capitalization factor. It illustrates how small-cap stocks are valued more highly than large-cap equities. The factor "SMB" is the average yield of small-cap stocks less the average return of large-cap companies. The market capitalization factor exists to capture the additional risk premium of smaller companies in the market relative to larger companies. This implies that, according to the CAPM's premise that only market risk is taken into account, small-cap companies may have higher risk as well as larger potential profits.

Included in the FF3 model, the book-to-market ratio factor illustrates the value of value stocks relative to growth stocks." High Minus Low" represents the average return of high book-to-market stocks minus the average return of low book-to-market stocks [7]. The book-to-market factor considers the different risk and return characteristics of the market between value stocks and growth stocks. This factor emphasizes investors' preference for cheaply valued stocks rather than just market capitalization size considerations.

Thus, the introduction of the FF3 model makes the asset pricing model for capital markets more complex but also more relevant to actual market conditions. The emergence of this model marks the evolution of capital market pricing theory and provides more perspectives and strategies for investment and risk management [8].

The FF5 model, which expands on the original three-factor model by including three additional elements, was further proposed by Fama and French: the market risk factor with market capitalization weight, the profitability factor with market capitalization weight, and the market capitalization-weighted investment model factor [9]. The five-factor model is more complex and takes into account more risk factors, which makes the relation between asset return and risk easier to understand. It has made notable progress in determining which investment strategies are most productive and understanding anomalous stock market results [10].

The CAPM, the FF3 model, and the FF5 model represent different stages of continuous improvement and expansion of asset pricing models. Each has unique advantages in explaining asset returns and risks and applies to different market environments and research purposes [11]. The development of these models reflects the relentless pursuit of a more accurate and comprehensive asset pricing methodology in the field of finance.

2. Methodology

The methodology section is the cornerstone of the study, which consists of two key aspects: 1) the selection and acquisition of data, which includes data sources, time span, sample selection, etc.; and 2) the construction of the model, which involves the theoretical foundations of the model, the selection of variables, and the measurement methodology. The careful design and execution of these two aspects are crucial to the accuracy and credibility of the study.

2.1. Data Selection

The period of this study covers data from January 3, 1994, to December 25, 2023, and the main

subject of the study is the Chinese SSE A-share market (coded as P9701). To gain insight into the market characteristics, the study adopts a 2×3 portfolio segmentation methodology and categorizes stocks based on three different factors. These factors include market capitalization-to-book market capitalization ratio, market capitalization-to-operating profitability, and market capitalization-to-investment level.

For the market capitalization-book-to-market ratio classification, for example, the researcher chose the average market capitalization of the New York Stock Exchange as a watershed to categorize stocks into large-cap and small-cap categories. For the book-to-market ratio, the watershed was based on the 30th and 70th percentile of the NYSE, which categorized stocks into high, medium, and low. This segmentation method was performed three times and six different portfolios were generated each time.

To ensure the validity and reliability of the data analysis, data cleaning was performed in the study to remove data with extreme, missing, and unreasonable values. Eventually, the study obtained a daily sample size of 7,290 SSE A-share markets, which will be used to analyze and validate the predictive efficacy of the selected factors and their relationship with stock market returns.

2.2. Modelling

In the modelling section of this study, it will delve into the methodology and process of regression analysis using the least squares (OLS) method to examine the impact of the selected factors on the SSE A-share market returns. The steps involved in the modelling process are explained in more depth below.

2.2.1. Construction of Regression Equation

The CAPM, the FF3 model, and the FF5 model will be validated using the same data sample. By using a uniform data sample for testing, it aims to evaluate and compare the performance of each model in explaining stock market returns under the same market conditions, thereby comprehensively assessing their respective strengths and weaknesses in the context of the selected SSE A-share market data set.

CAPM is a single-factor model used to estimate the expected return of an asset. Here's how it is expressed:

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

(1) $E(R_i)$ symbolizes the asset's anticipated return.
(2) R_f the rate that is risk-free.
(3) β_i is an asset's beta coefficient concerning the market.
(4) $E(R_m)$ is the market's anticipated return as a whole.

The FF3 Model introduces two additional factors, considering the effects of market capitalization and value factors. Here's how it is expressed:

$$E(R_i) = R_f + \beta_i(R_m - R_f) + \beta_{SMB}SMB + \beta_{HML}HML \tag{2}$$

(1) β_{SMB} represents the beta coefficient of asset relative to SMB.
(2) β_{HML} represents the beta coefficient of asset relative to HML.

The FF5 Model extends the FF3 Model by adding three additional factors, providing a more comprehensive view of market risk factors. Here's how it is expressed:

$$E(R_i) = R_f + \beta_i(R_m - R_f) + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{RMW}RMW + \beta_{CMA}CMA \tag{3}$$

(1) β_{RMW} represents the beta coefficient of asset relative to RMW.

(2) β_{CMA} represents the beta coefficient of asset relative to CMA.

2.2.2. Parameter Estimation

By employing the Ordinary Least Squares (OLS) method, it embarks on the task of estimating the coefficients (weights) associated with each independent variable (see Table 1). The degree and direction of the link between these parameters and the dependent variable are represented numerically by these coefficients.

By minimizing the sum of squared residuals, OLS effectively identifies the coefficients that result in the best possible fit of the linear model to the observed data. This fitting process allows us to quantify how changes in each independent variable impact stock returns. Determining whether a rise in the market risk premium component corresponds to a rise or fall in stock returns is one example. Likewise, an analysis will be conducted to determine how market size, book-to-market ratio, profitability, and investment patterns affect stock returns within the framework of the Shanghai A-share market.

2.2.3. Coefficient Interpretation

Upon completion of the model construction and testing phase, it will conduct an in-depth analysis of the estimated coefficients to explain in detail the extent of each factor's impact on stock returns. For example, a quick question to analyze. Which variables significantly affect stock market returns, as indicated by their considerably non-zero coefficients? Which factors may not be very important in explaining stock returns because their coefficients are near zero? Other variables might affect stock market results favourably, and others might have the opposite effect.

3. Empirical Results

Table 1: Variable definitions.

Variable	Definition	Construction
RiskPremium	The "risk premium," or market risk premium factor, is the expected return that an asset will provide above the risk-free rate of return.	Usually, the risk-free rate of return is deducted from the overall stock market return to find the risk premium.
SMB	"SMB" stands for "small-minus-big," the size factor.	To identify small businesses from large businesses, the median market value is utilized.
HML	"HML" stands for the value factor "high-minus-low".	Three categories are created for companies based on the 30th and 70th of the book-to-market ratio.
RMW	The profitability metric "robust-minus-weak" is equivalent to "RMW."	Revenues minus expenses divided by book value of equity, with same delineation principle as HLM.
CMA	The investing metric known as "CMA" stands for "conservative-minus-aggressive."	Annual total asset changes divided by the total asset's end book value using the same delineation methodology as HLM.

The empirical research section is divided into three sections, each of which provides important information and insight into this study. First, descriptive statistics provides a comprehensive foundation for the study by providing an overall overview and characterization of the data. Next, regression results are the core of this study and provide insight into the impact of different factors on

stock returns through the degree of fit and coefficient estimates of the regression model. Ultimately, robustness tests are carried out to guarantee the dependability and uniformity of the findings under various circumstances.

3.1. Descriptive Statistics

This section will focus on the descriptive statistics of the FF3 model and the FF5 model as well as the detailed analysis of the correlation coefficients among the factors. Through Table 2, a comprehensive understanding of the distributional characteristics, means, standard deviations, and other important statistical properties of the factors is gained, which will provide insight into their performance in the Chinese SSE A-share market. In addition, focus on the correlations among the factors will help us identify potential correlations among different factors and further understand the interactions among market factors. This analysis will help to reveal the behaviour and interrelationships of the factors in the Fama-French model in the Chinese market.

3.1.1. FF5 Model

Table 2: Summary statistics of the FF5 model.

variable	mean	sd	p25	p50	p75	min	max	t-statistics
RiskPremium	0.0963%	2.0501%	-0.6740%	0.0732%	0.8202%	-17.1708%	39.5313%	133.836
SMB	0.0359%	0.8148%	-0.3400%	0.0726%	0.4775%	-8.0157%	5.4455%	9.468
HML	0.0096%	0.7275%	-0.3602%	-0.0197%	0.3406%	-6.9630%	8.0425%	-7.967
RMW	0.0015%	0.6595%	0.3357%	-0.0124%	0.3200%	-7.3030%	6.1598%	-1.210
CMA	0.0008%	0.6613%	0.2971%	-0.0054%	0.2900%	-6.6978%	9.3598%	-2.833

The RiskPremium shows the average performance of asset returns relative to the risk-free rate, despite volatility, has shown positive returns overall. The Market Capitalization Factor (SMB) reveals that small-cap stocks may realize a slight return premium in certain market conditions, hinting at the potential impact of market capitalization size on stock returns. HML reflects the return premium of value stocks relative to growth stocks, even though growth stocks outperform half the time. The profitability factor (RMW) suggests that more profitable companies may have a slight return premium, but their return performance fluctuates widely across market conditions. Finally, the Investment Model Factor (CMA) suggests that conservative companies may realize a slight return premium in some periods, however, non-conservative companies may outperform in the other half of the time.

Table 3: FF5's correlation matrix.

	RiskPremium	SMB	HML	RMW	CMA
RiskPremium	1				
SMB	0.0224	1			
HML	0.0429	-0.3422	1		
RMW	-0.1084	-0.5570	0.1728	1	
CMA	0.0267	0.2711	0.1006	-0.3788	1

The correlation analysis in the FF5 model (see Table 3) shows that there is a negative correlation between SMB and HML, suggesting that small-capitalization stocks may perform relatively better under certain market conditions and that value stocks may have an advantage over growth stocks. There is also a negative correlation between SMB and RMW, which implies that small capitalization stocks may perform better relative to highly profitable companies.

3.1.2. FF3 Model

Table 4: Summary statistics of the FF3 model.

variable	mean	sd	p25	p50	p75	min	max	t-statistics
RiskPremium	0.0963%	2.0501%	-0.6740%	0.0732%	0.8202%	-17.1708%	39.5313%	134.384
SMB	0.0358%	0.9126%	-0.3645%	0.0733%	0.5172%	-9.0838%	5.9215%	13.043
HML	0.0096%	0.7276%	-0.3587%	-0.0213%	0.3384%	-6.9630%	8.0425%	-7.994

Based on the descriptive statistics of the FF3 model (see Table 4), the return performance between the different factors can be observed. The RiskPremium has positive returns on average but is characterized by high volatility and may show significant positive returns in some cases. The Market Capitalization factor (SMB) has lower returns on average, but also has greater volatility, and small-capitalization stocks may outperform relative to large-capitalization stocks in certain market conditions. HML has smaller average returns but is more volatile and value stocks may have a return premium relative to growth stocks in certain periods.

Table 5: FF3's correlation matrix.

	RiskPremium	SMB	HML
RiskPremium	1		
SMB	0.0543	1	
HML	0.0463	-0.3323	1

Based on the correlation coefficient matrix of the FF3 model (see Table 5), the following can be inferred. There is a degree of positive correlation between the RiskPremium and the SMB and HML, suggesting that depending on the state of the market a high market capitalization and a high book-to-market ratio may go hand in hand with a high RiskPremium. HML and SMB have a high negative association, suggesting that small-cap stocks are likely to be perceived as value stocks compared to large-cap stocks and vice versa.

3.2. Regression Results

Table 6: Model performance comparison with a whole market portfolio.

Variables	(1)	(2)	(3)
	CAPM	FF3	FF5
RiskPremium	0.9730*** (0.000)	0.8353*** (0.000)	0.8377*** (0.000)
SMB	-	0.1929*** (0.000)	0.1886*** (0.000)
HML	-	-0.1484*** (0.000)	-0.1521*** (0.000)
RMW	-	-	-0.0295 (0.226)
CMA	-	-	-0.0605*** (0.005)
Constant	-0.0089*** (0.000)	-0.0093*** (0.000)	-0.0093*** (0.000)
Observations	7,290	7,290	7,290
R-squared	0.855	0.719	0.718

Drawing from the regression outcomes of the three models displayed in Table 6, a significant

conclusion has been arrived. It is not the more explanatory factors the better, but it needs to choose the appropriate model according to the specific situation. The inherent impression is that the five factors should have the best explanatory power. In this study, for the Chinese stock market dataset, the FF3 model shows the best explanatory results.

This finding emphasizes the importance of model selection, especially under different conditions, such as different stock markets. Although the FF5 model introduces more factors to explain return differences more comprehensively, it does not mean that it performs best in all cases. The Chinese stock market has unique characteristics and policy environments that differ from the European and U.S. markets, thus requiring careful selection of an appropriate model.

This observation emphasizes the importance of market characteristics and context that researchers should consider when selecting an asset pricing model. Certain models may be more appropriate for explaining asset returns and risks in different markets and time horizons, while others may not. Therefore, considering a combination of market characteristics and the explanatory power of models to predict the performance of equity markets more accurately is a key point in asset pricing research.

3.3. Robustness Check

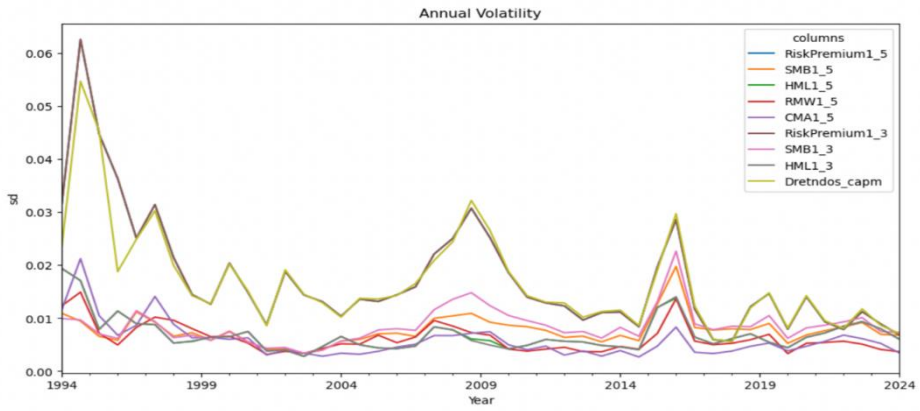

Figure 1: Annual standard deviation of all factors in three asset pricing models from 1994 to 2023.

The three time periods 2002-2006, 2010-2014, and 2017-2021 were chosen for regression analysis with the aim of assessing the robustness of the FF3 model. To more precisely test the model's performance in a relatively stable market environment, the decision was made to omit the effects of the 2008 financial crisis and the significant stock market developments in 2015 (see Figure 1).

Table 7: Comparison of sub-periods on FF3 model robustness check.

Variables	(1)	(2)	(3)
	2002-2006	2010-2014	2017-2021
RiskPremium	0.9882***	1.0259***	1.0308***
	(0.000)	(0.000)	(0.000)
SMB	0.2160***	0.1990***	0.1603***
	(0.000)	(0.000)	(0.000)
HML	-0.1335***	-0.1853***	-0.2183***
	(0.000)	(0.000)	(0.000)
Constant	-0.0060***	-0.0081***	-0.0042***
	(0.000)	(0.000)	(0.000)
Observations	1,204	1,212	1,217
R-squared	0.970	0.986	0.988

Overall, these results show that the FF3 model exhibits a good fit and is robust over the three subintervals of 2002-2006, 2010-2014 and 2017-2021 (see Table 7). This implies that the model is effective in explaining changes in stock market returns over time and provides investors with a useful tool to assess and predict market performance.

4. Conclusion

Regression examination of data from the Chinese SSE A-share market from 1994 to 2023 reveals that the FF3 model has the greatest performance on this set of data. In addition to accounting for market risk, the model also takes into account market capitalization and book-to-market ratio factors, which together provide a more thorough explanation for the variations in stock returns. This finding highlights how important it is to take into account both the model's explanatory ability and the features of the market when choosing an asset pricing model.

There are some limitations. 1) Data limitation. This study used the SSE A-share market data from 1994 to 2023, but the market environment and policies may change in different time periods, so the results may be affected by a specific time period. 2) Model selection. This study only considers three classical asset pricing models and does not cover other possible models or factors. There may exist models that are more suitable for the Chinese stock market. 3) Market Characteristics. The Chinese stock market has unique characteristics and policies that are different from the international market, so the results of the study may not apply to other countries or regions.

Future research can be expanded in the following directions. 1) Model improvement including adding more factors to improve the forecasting ability. 2) Stock markets in different regions of China can be studied and the differences in model performance between them can be compared to gain insight into regional characteristics.

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