Optimal Application of ESG Indicators and Traditional Five-Factor Indicators in China's Investment Market

You Li

Nanjing University of Science and Technology, Nanjing, China

Abstract. Based on the A-share listing formula from May 2000 to April 2023, this paper examines the application of the traditional five-factor model and the new five-factor model with ESG in China's investment market. It is found that the five-factor model in China's stock market has a very strong explanatory ability, but there are also certain shortcomings, such as the role of the CMA factor of investment ability is not significant, so the empirical design of replacing the CMA factor with ESG factor is proposed, and a variety of grouping methods are proposed in the design of ESG factors, and finally the new factor model with ESG is compared with the traditional five-factor model through a large number of empirical data and GRS test, and the new factor model with ESG has stronger explanatory ability.

Keywords: Fama-French five-factors, ESG, Asset pricing, China stock market.

1. Introduction

Driven by global trends and growing public attention to sustainability, there have been increasing intense discussions on the social responsibilities that enterprises should undertake. Key areas such as climate change, energy transition, "dual carbon" goals, sustainable development, green finance, and green transformation have become the focus of strategic layouts of countries around the world. Meanwhile, with the progress of the times, more enterprises, their management teams, and relevant investors have recognized that fulfilling and undertaking corresponding social responsibilities is an obligatory duty of enterprises. In recent years, global warming and major public health incidents such as COVID-19 and monkeypox have frequently caused severe impacts on society and the economy, making sustainable development capabilities and non-financial information disclosure key focuses of enterprises and investors. ESG, which stands for Environment, Social, and Corporate Governance, is an indicator that aligns with the current background of economic and social development. Many researchers have recognized the importance of this indicator and its strong correlation with corporate value. The information contained in ESG also provides strong support for investors to analyze the sustainable development capabilities of enterprises and identify potential risks.

As a stock market dominated by investment activities, China's stock market is still relatively young and in a stage of unstable development. In addition, most domestic investments are still based on traditional analysis methods, with few quantitative investment and trading practices, and relevant research is not in-depth enough, requiring further exploration. At the same time, this paper incorporates the ESG factor to further optimize the quantitative results and study the impact of ESG information on the effectiveness of the stock market.

At present, domestic research on ESG investment is still in the initial stage, and there is no systematic, complete, and cutting-edge theoretical and practical research in the domestic academic and industrial circles. To improve the theoretical foundation of ESG investment, this paper intends to promote the development of ESG responsible investment through a combination of theoretical and empirical methods. Therefore, starting from the CAPM (Capital Asset Pricing Model) theory of asset pricing models, this paper first constructs an ESG-CAPM model, and finally develops from the traditional single-factor asset pricing model to the multi-factor Fama three-factor and five-factor models. This paper introduces the relevant theories of FF5 (Fama-French Five-Factor Model) and combines the current situation of China's capital market. First, it empirically tests the effectiveness of the Fama five-factor model in the Chinese market. After verifying the effectiveness of the five factors, it further constructs a Fama five-factor + ESG model to test the feasibility of the ESG asset

pricing model, that is, to explore whether ESG investment portfolios can bring excess returns to investments and answer questions such as whether responsible investment creates value.on.

2. Literature Review

2.1. Domestic and Foreign Research on ESG Investment

Socially Responsible Investment (SRI) is a rapidly emerging phenomenon in the field of personal investment. Peifer (2014) explored how economic and ethical issues affect shareholders' investment behaviors.

Juravle and Lewis (2008) attempted to identify various obstacles to SRI in Europe from the perspective of institutional investors and proposed unified SRI obstacles using different relevant research perspectives such as behavioral finance, organizational behavior, institutional theory, economic sociology, management, and finance. Perez Gladish et al. (2013) tried to integrate traditional and socially responsible mutual funds within the framework of data envelopment analysis based on second-order stochastic dominance efficiency, but the results did not show that traditional mutual funds performed better. Leite and Cortez (2014) analyzed the performance and investment styles of SRI funds in eight European markets. The results showed that there is no statistically significant difference in performance between international SRI funds and their traditional counterparts.

Bax, Karoline et al. (2021) studied whether ESG scores can be used to provide information on (tail) risks. By analyzing the (tail) dependence structure of companies with a range of ESG scores (i.e., within ESG rating levels) using a high-dimensional vine copula model, the results showed that risks are directly related to specific ESG rating levels, and the ESG risks determined by ESG scores are positive, especially during the 2008 crisis. Luo (2022) studied the impact of ESG scores on stock returns in the United Kingdom (UK). Consistent with Hong and Kasprzyk (2009), Pedersen et al. (2020), and Bolton and Kasprzyk (2021), when evaluating cross-sectional data of 14,400 companies in 77 countries, the results showed that higher carbon emission levels and growth rates are associated with higher stock returns in all industries and most countries. All the above conclusions indicate that companies with low ESG scores earn higher returns than those with high ESG scores, and the return premium may be related to stock liquidity.

Górka, Joanna et al. (2022) studied the return volatility and correlation of ESG indices and traditional indices, and calculated their tail dependence coefficients using GARCH modeling and copula-based methods. The analysis covered the period from 2007 to 2019. The results confirmed that the degree of extreme value dependence is higher during crisis periods and lower during stable periods. Plastun, Alex et al. (2022) studied the differences between ESG and traditional indices, as well as the price effects related to daily abnormal returns of stock market indices in developed and emerging countries. The results showed that the price effects of traditional indices after daily abnormal returns are stronger than those of ESG indices.

2.2. Asset Pricing Models

Foreign research on quantitative investment started earlier. In 1952, Harry M. Markowitz's paper "Portfolio Selection" became the starting point of quantitative investment research. Different from the qualitative research of traditional investment, he quantified returns and risks using the mean of portfolio returns and the variance of returns, and proposed the classic Mean-Variance (MV) model. Later, due to the complexity of calculation and difficulty in understanding of the MV model, the Capital Asset Pricing Model (CAPM) emerged, proposed by Sharpe, Lintner, and others. This model assumes that all investors in the market make investments based on the mean-variance theory, thereby expressing the expected return and risk of assets through a linear equation.

3. Introduction to Relevant Theories

3.1. Fama-French Factor Model

In 1993, based on the CAPM and drawing on Ross's arbitrage theory, Fama and French used stock data from 1963 to 1991 to establish a linear return model with three factors: market capitalization factor (SMB), book-to-market ratio factor (HML), and market risk premium factor (R_m-R_f),With the continuous research and empirical studies on the capital asset pricing model, scholars have successively found that there are some returns in the stock market that cannot be fully explained by the three-factor model. Therefore, Fama and French further improved the three-factor model by adding the profitability factor (RMW) and investment factor (CMA) to propose the five-factor model. Its formula is:

$$R_{it}-R_{ft}=\alpha_i+b_i(R_{mt}-R_{ft})+s_iSMB_t+h_iHML_t+r_iRMW_t+c_iCMA_t+\varepsilon_{it} \quad (1)$$

Among them,α_i is the intercept term, and b_i, s_i, h_i, r_i, c_i are the coefficients of each factor. R_{ft} represents the risk-free rate of return at time t,R_{it} represents the rate of return of asset i at time t, R_{mt} represents the rate of return of the market portfolio at time t, and R_{mt}-R_{ft} is the market risk premium at time t. The specific construction and calculation methods of each factor will be provided in the empirical test.

3.2. GRE Test

The GRS test is a test method proposed by Gibbons, Ross, and Shanken in 1989 to test whether the asset pricing model is rejected. They constructed a statistic called the GRS statistic, which is expressed when there are K factors in a multi-factor pricing model:

$$GRS=(\frac{T}{N})(\frac{T-N-K}{T-K-1})\left(\frac{\widehat{a'}\widehat{\sum}^{-1}\hat{a}}{1+\overline{\mu'}\hat{\Omega}^{-1}\overline{\mu}}\right)\sim F(N,T-N-K) \quad (2)$$

The F distribution of the obedience degrees of freedom is N and T-N-K. T represents the number of periods of monthly data, N represents the number of portfolios, is an N*1 dimension column vector composed of regression constant terms$\hat{a}$, $\widehat{\sum}$represents the covariance matrix of regression residuals, represents the covariance matrix of factors, and is only a K*1 dimension column vector composed of the sample mean of the factors.

The null hypothesis of the GRS test is H0:a1=a2=...=a25=0, where ai represents each regression constant term and the intercept term is 0 at the same time, indicating that the rate of return can be fully explained by each factor. If the GRS test statistic is larger, the smaller the p-value of the test, the more it can reject the null hypothesis, and the intercept term of the 25 regressions is not significantly 0, that is, the model is not well fitted and the explanatory ability is poor. On the contrary, if the statistic of the GRS test is smaller, the larger the p-value, the less the null hypothesis cannot be rejected, the more we can think that the intercept term of the regression is significantly 0, the more significant the intercept term is 0, and the more the proof factor can fully explain the excess return of the stock, the better the model fits, so we hope that the p-value of the test will be as large as possible when doing the GRS test.

3.3. ESG Responsible Investment Evaluation System

Based on ISO2600, SASB, and GRI, ESG is defined and rated from multiple dimensions and levels. At present, there are five institutions in the world, including MSCI, Dow Jones, Thomson Reuters, FTSE and Morning Star, which are ESG ratings or ratings. However, since this paper is mainly based on in-depth research on ESG in China's asset market, international ESG theories and rating indicators can be used as reference standards for domestic ratings and quantification. At present, the only ESG data available to us is the CSI ESG rating since 2009, which is also the source of the empirical data of this article, the Huazheng ESG rating system is based on the actual situation of the domestic market, through the core connotation of ESG in-depth research, the establishment of a three-level indicator

rating system, mainly including E, S and G 3 first-level indicators, 14 second-level indicators, 26 third-level indicators and hundreds of underlying data logic. In ESG ratings, an AI-powered data engine is employed, with a combination of dynamic tracking and static quarterly ratings. Nine ESG ratings were given to listed companies of "C-AAA".

4. Empirical Analysis of the Five-Factor Model

4.1. Data Selection and Processing

4.1.1. Data Preprocessing

A-shares in China's stock market include the main board and ChiNext board of Shanghai A-shares and Shenzhen A-shares. They account for the majority of the total market value and quantity of listed companies in China's stock market, and to a large extent represent China's stock market. Considering that domestic institutions, organizations, and individuals in China mainly participate in A-share transactions, the stock samples in this paper only include A-shares.

Therefore, this paper selects all A-shares as the research object, and downloads the monthly stock data of all A-shares from 2000 to 2023 and the relevant annual data within this period from the CSMAR database.

The downloaded data is cleaned by excluding stocks that have been listed for less than 6 months and stocks marked with ST, *ST, PT, etc. (ST stands for Special Treatment, referring to stocks with abnormal financial or other conditions; PT stands for Particular Transfer, referring to stocks that are suspended from listing due to consecutive losses and undergo special transfer). At the same time, considering that the asset-liability structure of enterprises in the financial industry is significantly different from that of companies in other industries, financial stocks are excluded. Then, data cleaning work such as unifying measurement units, deleting duplicate data, and removing missing and invalid data is completed to prepare the sample data.

Table 1. Factor name and selection range

Factor name	Factor Selection Scope (2000-2023)
SIZE(Market Cap)	The total outstanding share capital disclosed in the financial statements of the previous year is calculated by multiplying the closing price of the last trading day of the previous year
B/M(Book to Market Ratio)	The book value of the owner's equity disclosed in the financial statements of the previous year is divided by the book market value of the circulating market value on the last trading day of the previous year
OP (Profit)	The ratio of operating profit to total owner's equity in the previous year's financial report
INV (Investment)	The ratio of the change in total assets in the previous year's financial report to the size of total assets two years ago

4.1.2. Interpreting variable calculations

The five factors of the Fama-French five-factor model are risk-return factor, market capitalization factor (SMB), book to market value ratio factor ((R_{mt}-R_{ft})HML), profitability factor (RMW) and investment factor (CMA).The model expression is:

$$R_{it}-R_{ft}=\alpha_i+b_i(R_{mt}-R_{ft})+s_iSMB_t+h_iHML_t+\varepsilon_{it}$$

If the research object is a single stock, its value can be obtained directly from the database, if the research is a portfolio, its value can be obtained by the return of individual stocks in the portfolio in equal proportion or weighted according to the market capitalization, this paper uses the monthly stock return data, and the circulating market value is weighted in the grouping calculation. It is the$R_{it}R_{ft}$ market risk-free rate of return at time t, the value of which can be replaced by the RMB interest rate announced by the People's Bank of China or the interest rate of government bonds, and the risk-free interest rate in this article adopts the one-year time deposit interest rate; R_{mt}It is the market portfolio yield under time t, the portfolio here refers to the combination of all risk assets in the market, including

stocks and other financial assets as well as gold and other physical assets, in reality it is difficult to build such a portfolio, so its value is often calculated by the market index, this data can also be directly obtained from Guotai An and other databases, this paper uses the market value weighted average considering the comprehensive monthly market return of cash dividend reinvestment; reflects the market risk premium at time t; is the intercept term, which refers to the part of the rate of return that cannot be explained by the factors in the model; SR_{mt}-$R_{ft}\alpha_i$MB is obtained by calculating the difference in yield between small and large market capitalization stock portfolios; HML is obtained by calculating the difference between high and low book market capitalization ratio to the yield of the stock portfolio; RMW represents the profitability of a company, which is obtained by subtracting the yield of a stock portfolio with high operating profit minus the yield of a stock portfolio with low operating profit; The CMA investment factor is calculated by subtracting the return of a portfolio of stocks with a conservative investment style minus the return of a portfolio of stocks with an aggressive investment style.

Table 2 shows the construction methods of each factor under the 2*2 grouping method, and due to the grouping data of ESG, the use of 2*2 can be better compared.

Table 2. Grouping factor construction method

Category	Ways
grouping	The ratio of circulating market value to book market value is 2*2 grouping
	Circulating market value and profitability are grouped 2*2
	Circulating market value and investment level are grouped 2*2
grouping points	Circulating Market Cap (SMB): Median, divided into two groups: S and B, from small to large
	Book to Market Value Ratio (HML): Median, divided into two groups: H and L, from small to large
	Profitability (RMW): Median, from small to large, divided into two groups: R and W
	Investment level (CMA): median, from small to large, divided into two groups: C and A
compute	SMB=(S+SL+SR+S+SC+Sa)/6-(V+BL+BR+Bu+BC+BA)/6
	HML=(SH+BH)/2-(SL+BL)/2=[(SH-SL)+(BH-BL)]/2
	RMW=(SR+BR)/2-(SW+BW)/2=[(SR-SW)+(BR-BW)]/2
	CMA=(SC+BC)/2-(SA+BA)/2=[(SC-SA)+(BC-BA)]/2

4.2. Data collection with new ESG models

If the rating data is collected on a monthly basis, from 2009 to 2021, a total of 154 statistics will be collected for 13 years, and the factors and grouping combinations will basically not meet the statistical significance characteristics, so we will reduce the data collection to once a week, with a total of 677 collections. The number of stocks and ESG ratings are updated semi-annually, and all groups are regrouped according to the original rules for new stock portfolios and ESG. Finally, considering that the shell resources and book value of all A-shares are negative, there may also be value divergence, so the market value at the beginning of the year is sorted, excluding the last 10% of the market value, excluding stocks with suspension and negative book value.

4.3. Data collection with new ESG models

4.3.1. Interpreting variable calculations

Because the CSI ESG rating is a total of 9 discrete ratings from C, CC, CCC, BBB, BB, B, A, AA, and AAA, and there are only 2-3 ratings in the early stage of data traceability, and the data is extremely difficult to cut. Therefore, all the subsequent groups only divide ESG into 2 groups. Therefore, the 2*2 factor grouping method is uniformly adopted in this paper. The traditional factor construction method is generally combined with Size and other factors, and the specific structure is as follows.

Through the construction method of the above table, we perform basic statistics on the data of the factors, because we find that the statistical t value of the Size and ESG combination is too small, and try to add other groupings such as B/M-ESG grouping and OP-ESG grouping, the specific data are as follows:

Table 3. Descriptive analysis of new factors

	mean	Sd	t-statistics
R_{mt}-R_{ft}	0.790	7.970	1.77
SMB	0.371	3.653	4.10
HML	0.198	3.741	0.94
RMW	0.247	3.130	4.21
ESG_SE	0.04	0.67	0.15
ESG_BE	-0.32	0.72	-1.14
ESG_OE	-0.34	0.72	-1.12

From the above table, it can be clearly seen that the statistical attributes of ESG_SE factors are very inconspicuous, and the t-value = 0.15 is too small, so we try to construct new factors with other combinations, namely the ESG_BE of the B/M-ESG combination and the ESG_OE of the OP-ESG combination, and only the t-values of the ESG_BE and ESG_OE are -1.14 and -1.12, respectively, indicating that the two factors are slightly better than ESG_ SE factor, and the value of the two factors is less than zero, indicating that the factor is constructed in the opposite way. It has been verified that it is more suitable to replace Size-ESG grouping with B/M-ESG or OP grouping.

4.4. New five-factor model test

Table 4. GRS validation of the new five-factor full group and whole model

grouping	New factor	GRS	A|α_i|
10*2 Size-ESG	ESG_SE	1.724	0.372
	ESG_BE	1.684	0.374
	ESG_OE	1.687	0.373
10*2 B/M-ESG	ESG_SE	0.810	0.372
	ESG_BE	0.870	0.374
	ESG_OE	0.810	0.373
10*2 OP-ESG	ESG_SE	2.074	0.372
	ESG_BE	1.900	0.374
	ESG_OE	1.905	0.373
4*4*2 Size-B/M-ESG	ESG_SE	2.139	0.372
	ESG_BE	2.046	0.374
	ESG_OE	2.071	0.373
4*4*2 B/M-OP-ESG	ESG_SE	1.427	0.372
	ESG_BE	1.300	0.374
	ESG_OE	1.315	0.373
4*4*2 Size-OP-ESG	ESG_SE	2.139	0.372
	ESG_BE	2.046	0.374
	ESG_OE	2.071	0.373
2*2*2*2 Size-B/M-OP-ESG	ESG_SE	0.866	0.372
	ESG_BE	0.918	0.374
	ESG_OE	0.888	0.373

The null hypothesis of the GRS test is that the constant terms of the 25 sets of regression are all zero, and the intercept term is 0 at the same time, indicating that the rate of return can be fully explained by each factor. If the p-value of the GRS test is less than 0.05, that is, the null hypothesis is rejected at the level of 0.05, and the intercept term is considered to be zero when the intercept term is different, that is, the model explanation is not strong enough, and there are excess returns that

cannot be explained by each factor. Therefore, the smaller the statistic and the larger the p-value, the closer the intercept term is to zero, and the less the model can be rejected, indicating that the model interpretation effect is better.

The whole stock is divided into 25 asset portfolios, and the GRS model is used to review the intercept terms after regression, and the results are shown in Table 4. Combined with the performance of each factor in cross-group regression, the CMA factor outperformed the HML factor in the regression, which was indispensable for the model interpretation, and this paper was also tested when the data collection was still two months away, and the CMA factor was not redundant. Therefore, it can be considered that the HML factor does not have a great effect on the explanatory effect of the model in the sample interval of this paper, but this test does not show that HML is redundant in the pricing predictor of the Chinese stock market.

5. Summary

This paper first conducts a comparative analysis of the applicability of the Fama-French five-factor model in the same-span sample intervals before and after the share reform. It is found that the model has a certain explanatory effect on China's A-share market both before and after the share reform, but its applicability is higher in the early stage of the share reform, and the HML factor has always been redundant. Generally speaking, the explanatory power of the Fama-French five-factor model is not perfect, and there are other factors that can explain part of the returns.

This paper integrates ESG factors into the modern financial theory system, establishes a five-factor model based on ESG information according to the time characteristics of asset prices, and expounds the application value of ESG and asset pricing models. In particular, when the impact of ESG information on operating profit is greater than that on investment expenditure, it means that enterprises are more willing to retain profits in the company based on ESG information. For companies with ESG information ratings higher than the market average, the corresponding stock prices are higher; on the contrary, investors will impose certain penalties, resulting in lower stock prices.

This paper conducts an empirical study combined with the five-factor model. The empirical conclusion shows that ESG information has a significant impact on investment returns. The traditional five-factor model and the new five-factor model with ESG information are constructed respectively through empirical methods for comparative analysis. In terms of ESG rating data, the ESG ratings of A-share listed companies from 2009 to 2021 in the Huazheng ESG Rating are selected to construct a full-sample stock portfolio, and the weekly data within the sample interval is selected for empirical testing. The research conclusion shows that the ESG factor plays a significant role, and its application in the five-factor model is more suitable for the Chinese market.

References

[1] C Peifer J L. Fund loyalty among socially responsible investors: The importance of the economic and ethical domains [J]. Journal of Business Ethics, 2014, 121: 635 - 649.

[2] Williams G. Some determinants of the socially responsible investment decision: A cross-country study [J]. Journal of Behavioral Finance, 2007, 8 (1): 43 - 57.

[3] Crifo P, Forget V D, Teyssier S. The price of environmental, social and governance practice disclosure: An experiment with professional private equity investors [J]. Journal of Corporate Finance, 2015, 30: 168 - 194.

[4] Statman M. Socially responsible indexes: Composition, performance, and tracking error [J]. Journal of portfolio Management, 2006, 32 (3): 100 - 109.

[5] Juravle C, Lewis A. Identifying impediments to SRI in Europe: A review of the practitioner and academic literature [J]. Business Ethics: A European Review, 2008, 17 (3): 285 - 310.

[6] Leite P, Cortez M C. Style and performance of international socially responsible funds in Europe [J]. Research in International Business and Finance, 2014, 30: 248 - 267.

[7] Kolstad I. Three questions about engagement and exclusion in responsible investment [J]. Business Ethics: A European Review, 2016, 25 (1): 45 - 58.

[8] Borgers A, Derwall J, Koedijk K, et al. Stakeholder relations and stock returns: On errors in investors' expectations and learning [J]. Journal of Empirical Finance, 2013, 22: 159 - 175.

[9] Sievänen R, Rita H, Scholtens B. The drivers of responsible investment: The case of European pension funds [J]. Journal of business ethics, 2013, 117: 137 - 151.

[10] Bax K, Sahin Ö, Czado C, et al. ESG, Risk, and (tail) dependence [J]. International Review of Financial Analysis, 2023, 87: 102513.

[11] Luo D. ESG, liquidity, and stock returns [J]. Journal of International Financial Markets, Institutions and Money, 2022, 78: 101526.

[12] Hong H, Kacperczyk M. The price of sin: The effects of social norms on markets[J]. Journal of financial economics, 2009, 93 (1): 15 - 36.

[13] Bolton P, Kacperczyk M. Global pricing of carbon-transition risk [R]. National Bureau of Economic Research, 2021.

[14] Górka J, Kuziak K. Volatility modeling and dependence structure of ESGand conventional investments [J]. Risks, 2022, 10 (1): 20.

[15] Plastun A, Bouri E, Gupta R, et al. Price effects after one-day abnormal returns in developed and emerging markets: ESGversus traditional indices [J]. The North American Journal of Economics and Finance, 2022, 59: 101572.

[16] Markowits H M. Portfolio selection [J]. Journal of finance, 1952, 7 (1): 71 - 91.

[17] Sharpe W F. Capital asset prices: A theory of market equilibrium under conditions of risk [J]. The journal of finance, 1964, 19 (3): 425 - 442.

[18] Sharpe W F. The sharpe ratio [J]. Streetwise–the Best of the Journal of Portfolio Management, 1998, 3: 169 - 85.

[19] Lintner J. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets: A reply [J]. The review of economics and statistics, 1969: 222 - 224.

[20] Fama E F, French K R. Common risk factors in the returns on stocks and bonds [J]. Journal of financial economics, 1993, 33 (1): 3 - 56.

[21] Fama E F, French K R. A five-factor asset pricing model [J]. Journal of financial economics, 2015, 116 (1): 1 - 22.