Differences in stock pricing efficiency between ESG-rated stocks and non-ESG-rated stocks

Yunhua Huang[1*+], Sheng Li[2+], Keyi He[3+], Tianyi Mao[4]

[1]Department of Economics, Xiamen University, Xiamen,361005, China
[2]Department of Maths and Statistics, Shenzhen University, Shenzhen,518060, China
[3]Department of Mathematics and Physics, Xi'an Jiaotong-Liverpool University, Suzhou, 215123, China
[4] Woodsworth College, University of Toronto St.George Campus, Toronto, M5S, Canada

+These authors contributed equally to this work and should be considered co-first authors.
*Corresponding author email: 1784889752@qq.com

Abstract. Environmental, social, and corporate governance, also known as ESG, has become mainstream in international enterprises by assessing the sustainability of business operations and their impact on social values from three dimensions of environmental, social, and corporate governance. Recently, it was gradually accepted by Chinese investors. Based on Chinese ESG rating and A-share market data from CSMAR, this paper constructs a novel Fama-French four-factor model to analyze the difference in their performances. The results show that: (1) the ESG-rated companies have significantly higher risk premiums than the unrated ones, indicating that the ESG rate is one of the price determinants; (2) compared with unrated companies, the rated ones have higher price efficiency; (3) in the rated group, the higher the rate is, the better the stock is priced. This study contributes to a better understanding of ESG stock performances in the Chinese market and the characteristics of ESG investment strategy, helping to further improve the exuberance of the Chinese A-share market.

Keywords: ESG Rating; Stock Pricing Efficiency; Risk premium

1 Introduction

Environmental, social, and corporate governance, also known as ESG, assesses the sustainability of business operations and its impact on social values from three dimensions: environmental, social, and corporate governance. and ESG has become mainstream in the international community. In China, the ESG concept makes green development accelerate. With the promotion of financial transformation policies, green bonds have exerted a corresponding ESG effect. However, China's green financial market still has shortcomings. This requires systematically collating investment theories in the context of the green economy, comparing ESG governance practices in other countries, and finding the best solutions for ESG green development in China. For investors, it is also

B. K. Kandel et al. (eds.), *Proceedings of the 2023 3rd International Conference on Business Administration and Data Science (BADS 2023)*, Atlantis Highlights in Computer Sciences 19,
https://doi.org/10.2991/978-94-6463-326-9_35

quite important to consider the role of the project in terms of environmental benefits and achieving long-term returns.

Achieving the optimal allocation of financial resources is the core function of the stock market and the ultimate goal of various reform policies formulated by government securities departments in various countries. At the same time, for ESG and green finance-related policies and development prospects, the efficiency of resource allocation in the capital market is still an important criterion for examination. The optimal allocation of financial resources in the capital market is accomplished through the signal function of stock prices, which in turn depends on its ability to reflect information about the intrinsic value of the company. That is, the efficiency of resource allocation in the stock market is determined by the efficiency of stock pricing. Theoretically, the efficiency of stock pricing can evaluate the effect of the policy. In recent years, China's "DOUBLE CARBON" policy and the implementation of the green sustainable development concept policy are essential to promote green environmental protection and low carbon and ultimately achieve the optimal allocation of financial resources. Thus, studying the impact of ESG on China's stock pricing efficiency can evaluate the policy effect, and also provides the theoretical basis and empirical support for the regulator to further improve the subsequent related policies, especially to further deepen sustainable investment, which has important practical significance.

In recent years, relevant studies on ESG have received the attention of some scholars. For example, Guojun An and Chao Hua study the impact of ESG system on the capital market [1]; Qun Cao and Qian Xu study how to construct ESG financial system [2]; Fangzhao Zhou and Hui Fu find that institutional investors have more significant stock holding preferences for ESG responsibility performance [3]; Jin Li studies the relationship between ESG ratings and average stock returns and risk premiums [4].

ESG can have an impact on share prices by improving the profitability and dividend yield of listed companies. However, little research has been conducted on the impact of ESG on stock pricing efficiencies, such as whether ESG has an impact on stock pricing efficiency, the extent of the impact, and its intrinsic transmission mechanism and economic principles. These questions are of great theoretical importance for exploring ESG and stock market pricing efficiency. Therefore, this paper selects a sample of constituents under Shanghai and Shenzhen A-shares and x A-share ESG index funds issued by CSI, HSC, and WAND from June 2015 to June 2019. Through extensive literature reading and data collection, we establish the Fama-French three-factor model and introduce the mathematical model of ESG variables to examine whether ESG is one of the pricing factors, and then analyze whether ESG rating affects the ESG index. The contributions of this paper are as follows: First, this paper innovatively combines the ESG score and ESG rating of individual stocks to examine whether ESG factors affect the price of individual stocks. This paper broadens the scope of the Fama-French three-factor model (Fama et al., 200X) and deepens the understanding of the relationship between corporate sustainability and corporate share price in the context of ecological civilization construction. Second, the changes in China's ESG market system provide an excellent natural experimental environment for studying the difference between the pricing efficiency of ESG index fund components and that of non-ESG stocks; only a

few stocks are assigned ESG ratings or scores, and various authorities have issued relevant index funds after the ratings, and the existing portfolio of index funds provides a natural experimental and control group for our study. Finally, the research in this paper responds to the national policies related to green finance and provides some help to promote rational stock selection for investors.

The remainder of the article is structured as follows: the second part is a literature review, which reviews and critiques relevant studies; the third part presents the research methodology and model building, and proposes hypotheses based on existing literature and market phenomena; the fourth part describes the research data; the fifth part reports and analyzes the empirical findings; the sixth part further analyzes the specific reasons for the changes in pricing efficiency, and finally concludes the full article.

2 Literature Review

2.1 The impact of ESG on corporate value

The literature on enterprise value focuses on corporate performance and the financial performance of companies, but how ESG affects the financial performance of companies and thus the enterprise value is still a controversial issue. Scholars have studied not only the three aspects of ESG indicators but also the impact of ESG performance as a composite score on enterprise value.

Qingxiang Zhu et al. showed that corporate environmental performance is positively correlated with corporate value, and the lower the industry concentration and the more intense the market competition, the more obvious this positive correlation is [5]. Mengyun Wu and Linrong Zhang obtained the corporate environmental responsibility index by the comprehensive weighting of environmental responsibility entries disclosed by listed companies, and the results of the study indicated that corporate environmental responsibility was positively correlated with corporate value [6]. The results of Kim et al. on the hospitality industry showed that CSR strengthening behavior increased Tobin's Q by increasing shareholder value, while CSR weakening behavior decreased shareholder value by increasing the systematic risk of the firm [7]. Wei and Hui et al. showed that corporate social responsibility can effectively reduce its corporate cost of equity capital, which in turn increases corporate value through the cost of capital effect [8]. Li et al. found that the efficiency of corporate governance and corporate performance of commercial banks are significantly positively correlated based on the DEA model empirically, and this positive correlation is more obvious in state-owned banks [9]. In addition, many scholars examine the impact on corporate value by using ESG performance as a composite score. Atan et al. analyzed 54 Malaysian listed companies from 2010-2013 ESG indicators and financial data as a research sample, and the regression results showed that none of the three types of indicators, environmental, social, or corporate governance, could individually influence a firm's profitability and firm value, but the combined scores of the three have a positive and significant impact on the firm's cost of capital [10]. Friede et al. used 2,200 ESG and financial performance papers as a study to explore the impact of ESG factors on a firm's financial performance. They

found that there is a positive relationship between ESG factors and firm financial performance, with better-performing firms having a lower cost of capital and higher stock price performance [11].

Regarding the impact of ESG factors on stock prices, Zengfu Li et al. examine the role of environmental, social, and governance (ESG) performance in stock prices during the financial crisis in the market triggered by the New Crown pneumonia epidemic. The results show that through ESG practices, firms can obtain significant reputational and risk protection to reduce price volatility in times of crisis, thus contributing to their long-term operations and sustainability [12].

2.2 A Review of Research on Stock Pricing

Stock pricing is a very important topic in the field of finance and a problem that many investors and policymakers must face. Since the Black-Scholes model was introduced in the 1970s, stock pricing theory has evolved and developed over several decades. In this paper, we will review some of the literature on stock pricing and briefly discuss the advantages and disadvantages of various models.

CAPM is one of the most commonly used models in the field of stock pricing. It was proposed by Sharpe, Lintner, and Mossin in 1964, and the model assumes that the expected return on an asset is proportional to the market risk premium and the beta of the asset. the CAPM model has been widely used to evaluate portfolios and measure the risk of stocks, but the model also has some problems. For example, the CAPM model assumes that investors are rational and can adequately diversify risk, which may deviate from reality.

To overcome the shortcomings of the CAPM model, many scholars have proposed some extensions of the model. Fama and French proposed a three-factor model in 1993, including market risk, firm size, and firm valuation factors. They found that firm size and firm valuation factors have significant effects on stock returns and explain the changes in stock returns better than the CAPM model. Based on this, Carhart proposed a four-factor model in 1997, which added a momentum factor, i.e., the price trend of stocks, in addition to the market risk and firm size and valuation factors. He found that the momentum factor could better explain changes in stock returns and could be used to explain the performance of mutual funds. Pastor and Stambaugh proposed a five-factor model in 2003 that included market risk, firm size, firm valuation, liquidity risk, and an earnings factor. They found that liquidity risk had a significant effect on stock returns and explained changes in stock returns better than the previous model. Fama and French further extended their model in 2015 by proposing a five-factor model that included market risk, firm size, firm valuation, investment, and earnings factors. They found that this model explains the variation of stock returns better than the previous model and is widely used in practice.

Summarizing the above literature, we can find that scholars at home and abroad have studied ESG-related content and stock pricing from different perspectives and by different methods, which can be mainly summarized as the study of the correlation between ESG performance and enterprise value from the perspective of companies and the study of stock pricing models, which provides an important reference base and value

inspiration for further research in this paper. However, it is not difficult to find that there are few studies on the impact of ESG on the efficiency of financial resource allocation from the market perspective. Therefore, this paper adopts a four-factor model to study the impact of ESG on stock pricing efficiency based on ESG ratings of domestic institutions and A-share market data.

3 Experiment Design

3.1 Basic Model

$Hypothesis\ 1$: ESG_{factor} has an influence on stock pricing

3.1.1 Linear regression model.

The $Fama-French$ three-factor model contains the value effect, market value effect, and several other elements. Then the $Fama-French$ five-factor model adds the earnings and investment level of the enterprise to this base. According to some relevant essays, the five-factor model has a better explanation of stock pricing in the Chinese stock market. Therefore, this paper selects the $Fama-French$ three-factor model as the basis of the pricing model construction, which uses unbalanced panel data, and introduces ESG evaluation factor based on the original variables to construct a four-factor model. The specific model is as follows:

$$R_{it} - r_f = \alpha_t + \beta_1 * \left(R_{mt} - R_f\right) + \beta_2 * SMB_t + \beta_3 * HML_t + \beta_4 * ESG_{factor} + \varepsilon_{it} \quad (1)$$

The explanatory variable stock yield of the individual company in time t. (2) r_f represents the Risk-free Rate. (3)R_{mt} demonstrates the Market Profitability in time t. (4) SMB_t measures the market value effect, which denotes the difference between the returns of the portfolio of companies with low market capitalization and the portfolio of companies with high market capitalization at time t. (5) HML_t measures the value effect, which demonstrates the difference in returns between the portfolio of companies with high book-to-market ratios and the portfolio of companies with low book-to-market ratios at time t. (6) In addition, Based on the research of Jane Li (2021), this paper constructs ESG_{factor} as the ESG evaluation factor, representing the difference between the returns of a portfolio of ESG-rated companies and a portfolio of non-ESG-rated companies and by testing whether this factor has a significant effect on stock returns and thus determines whether to be rated as ESG-rated companies can be used as a factor to influence stock pricing. The specific factor construction method is as follows:

Classification of the sample of all stocks into the rated group (R) and unrated group (UR) according to whether or not these enterprises received an institutional ESG rating at the end of period t-1.(2)Dividing the stocks of the rated group (R) into the small-cap group (S) and large-cap group (B) based on the median market value of stocks at the end of period t-1, then the (S) and (B) groups are divided separately into three groups of high (H), medium (M), and low (L) book-to-market ratios based on the 30% and

70% quartiles of the book-to-market ratio. In turn, the (R) group is eventually divided into six groups: SH, SM, SL, BH, BM, and BL. (3) The samples outside the range of the (UR) group are excluded according to the maximum and minimum values of the ratio of stock market value and book-to-market ratio of the (R) group. Then the remaining stocks are divided into six groups $SH_{UR}, SM_{UR}, SL_{UR}, BH_{UR}, BM_{UR}, BL_{UR}$ according to the same way of classification of the (R) group.(4)R_{mt} is equal to the return of the CSI 300 index at time t. Based on this, the calculation formulas of market value factor SMB_t, value factor HML_t and ESG evaluation factor ESG_{factor} are shown in Table 1:

Table 1. Calculation of the factors [Owner-draw]

Time	Quantile	Calculation formulas
size: end of period t-1 B/M ratio: end of year t-1	size:50% B/M ratio: 30%,70%	$SMB = \frac{\overline{R_{SH}} + \overline{R_{SM}} + \overline{R_{SL}}}{3} - \frac{\overline{R_{BH}} + \overline{R_{BM}} + \overline{R_{BL}}}{3}$ $HML = \frac{\overline{R_{SH}} + \overline{R_{BH}}}{2} - \frac{\overline{R_{SL}} + \overline{R_{BL}}}{2}$ $ESG_{factor} = \frac{\overline{R_{SH}} + \overline{R_{SM}} + \overline{R_{SL}} + \overline{R_{BH}} + \overline{R_{BM}} + \overline{R_{BL}}}{6} - \frac{\overline{R_{SH_{UR}}} + \overline{R_{SM_{UR}}} + \overline{R_{SL_{UR}}} + \overline{R_{BH_{UR}}} + \overline{R_{BM_{UR}}} + \overline{R_{BL_{UR}}}}{6}$

3.1.2 Hypothesis analysis.

Assumption: Stock pricing is closely related to individual stock returns. In this paper, we assume that the coefficient of the ESG evaluation factor ESG_{factor} in the linear regression model (1) is significantly negative, which indicates that controlling for other variables, rated stocks have lower average stock returns compared to unrated stocks. Normally lower returns imply less risk, thus demonstrating that rated stocks are able to better decline risk spillovers.

$Hypothesis\ 2$: Being ESG-rated can improve stock pricing efficiency

3.1.3 Measurement of stock pricing efficiency.

According to Zhisheng Li, Chen Chen, and Bingxuan Lin, the existing literature measures stock pricing efficiency mainly in terms of the information content of prices and the speed of information reflection of prices, therefore this essay introduces a pricing efficiency assessment factor ESG_{event_t} based on the former model to test whether participating in ESG ratings or not can affect stock pricing efficiency. In order to calculate the stock pricing efficiency, this paper forecasts each theoretical price $p_{t(ideal)}$ of the stocks one year after by applying the GARCH(1,1) model for each pricing and then calculate the relative difference between the theoretical price $p_{t(ideal)}$ and the real

price $p_{t(real)}$. Based on that, calculating the average relative error after taking the absolute value of the error and root mean square error, which is noted as AMRE, MSRE these two indicators. The specific calculation procedures are as follows.

Currently, a considerable body of empirical data and academic research has demonstrated the effectiveness of GARCH models for the time series modeling of financial data. The closing stock price in period t-1 and the stock return price in period t-1 are chosen as experimental data, then fitting the anticipated return r_t in period t by using the GARCH(1,1) model and calculating the theoretical price $p_{t(ideal)}$ in period t.

GARCH(p,q) model predicts volatility with the following equation:

$$\sigma_1^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \, \sigma_{t-j}^2 \left(\alpha_i \geq 0, i = 0,1 \ldots p; \beta_j \geq 0, j = 1,2 \ldots q\right) \quad (2)$$

Theoretical price calculation formula:

$$p_{t(ideal)} = (1+r_t) \, p_{t-1(real)} \quad (3)$$

Based on the study by Changfu Ma, Wei Xu, and Xianzhi Yuan (2019), in this paper, we set the predicted pricing series for each stock as $\left\{\boldsymbol{V}_i^{model}\right\}_{i=1}^{N}$ and the corresponding true pricing sequence is set as $\left\{\boldsymbol{V}_i^{market}\right\}_{i=1}^{N}$, calculating the average relative error after taking the absolute value of the error, which is recorded as AMRE,the calculation formula of AMRE:

$$AMRE = \frac{\sum_{i=1}^{N} \frac{\left|V_i^{model} - V_i^{market}\right|}{V_i^{market}}}{N} \quad (4)$$

In order to better reflect the larger deviation values, we also construct the root mean square error of the model, which is noted as $MSRE$, the calculation equation of $MSRE$ is as follows:

$$MSRE = \sqrt{\frac{\sum_{i=1}^{N} \left(\frac{V_i^{model} - V_i^{market}}{V_i^{market}}\right)^2}{N}} \quad (5)$$

3.1.4 Linear regression model.

After obtaining the AMRE and MSRE data, the pricing efficiency of rated and unrated stocks is further analyzed by event analysis methods. The model is constructed as follows:

$$Efficiency_{it} = \alpha_i + \beta_1 * Efficiency_{mt} + \beta_2 * SIZE_t + \beta_3 * BM_t + \beta_4 * ESG_{event_t} + \varepsilon_{it} \quad (6)$$

(1)$\text{Efficiency}_{\text{it}}$ is an indicator of pricing efficiency for each stock, which contains AMRE and MSRE. (2)$SIZE_{\text{t}}$, BM_{t} represent the ratio of the total market value and book-to-market of individual stocks at period t respectively.(3)The monthly average pricing efficiency $Efficiency_{mt}$ of all the stocks in period t is obtained by weighting and then averaging the monthly pricing efficiency indicators for all unrated and rated

stocks, which is regarded as the index of the market pricing efficiency and also contains elements like AMREm and MSREm. It's worth mentioning that the weight is the ratio of the total market value of an individual stock to the sum of the total market value of unrated and rated stocks. (4)Explanatory variable $\mathrm{ESG}_{\mathrm{event_t}}$ is the dummy variable, if the stock is rated at time t then the variable takes 1, otherwise, it takes the value 0. Generally the larger the absolute value of the coefficient of the element $\mathrm{ESG}_{\mathrm{event_t}}$, the more the pricing efficiency indicator of the stock portfolio is influenced by the ESG factor and the stronger the ability of the ESG factor to impact the pricing efficiency of the stock.

3.1.5 Hypothesis analysis

In this paper, we assume that in the linear regression model (2), The coefficient of the variable $\mathrm{ESG}_{\mathrm{event_t}}$ is significantly negative. This means that, controlling for other variables, rated stocks have smaller pricing efficiency indicators $\mathrm{Efficiency}_{\mathrm{it}}$ compared to unrated stocks, and smaller pricing efficiency indicators $\mathrm{Efficiency}_{\mathrm{it}}$ imply smaller errors between predicted and actual prices, making stock price forecasts more accurate and more efficient, thus proving that rated stocks have more accurate price forecasts and more efficient pricing.

$Hypothesis\ 3$: Higher ESG levels have positive influence on stock pricing efficiency

3.1.6 Classification of ESG stock ratings

Selecting all rated stocks as the experimental sample, the impact of different ESG ratings on stock pricing efficiency indicators is investigated by classifying rated stocks in two ways for all rated stocks.

$Method\ I$: Stocks rated A-, B+, and B are divided into one category and recorded as high-rated group H. Stocks rated B-, C+, and C are divided into another category and recorded as low-rated group L

$Method\ II$: Stocks rated A-, B+ are divided into one category and recorded as high-rated group H*, and stocks rated B-, C+, C are divided into another category and recorded as low-rated group L*.

3.1.7. Linear regression model.

After classifying ESG stocks with different categories, a linear regression analysis is performed on different categories of ESG stocks.

$$Efficiency_{r_{it}} = \alpha_i + \beta_1 * Efficiency_{r_{mt}} + \beta_2 * SIZE_{r_t} + \beta_3 * BM_{r_t} + \beta_4 * ESG_{rating_t} + \beta_5 * ESG_{rating} *_t + \beta_6 * year_t + \varepsilon_{it} \quad (7)$$

(1)$\mathrm{Efficiency}_{\mathrm{r_{it}}}$ is an indicator of pricing efficiency for all ESG-rated stocks, which contains $\mathrm{AMRE}_{\mathrm{r}}$ and $\mathrm{MSRE}_{\mathrm{r}}$. (2)The monthly average pricing efficiency of rated stocks $Efficiency_{r_{mt}}$ in period t is obtained by weighting and then averaging the monthly pricing efficiency indicators $\mathrm{Efficiency}_{\mathrm{r_{it}}}$ of all ESG individual stock, which

can be regarded as an indicator of market pricing efficiency and contain $\mathrm{AMREm_r}$ and $\mathrm{MSREm_r}$. The weight is the ratio of the total market value of an individual stock to the sum of the total market value of rated stocks. (3)$SIZE_{r_t}$, BM_{r_t} are the ratio of the total market value and book-to-market of the individual stock at period t for the rated stock respectively. Explanatory variables ESG_{rating_t} and $ESG_{rating} *_t$ are both dummy variables. (a) ESG_{rating_t} indicates that in the first classification method, high-rated group H stocks are taken as 1 and low-rated group L stocks as 0.

(b) $ESG_{rating} *_t$ indicates that in the second classification method, high-rated group H* stocks are taken as 1 and low-rated group L* stocks as 0.

(4) $year_t$ is the corresponding year.

3.1.8 Hypothesis analysis.

In this paper, we assume that in the linear model (3), the coefficients of both explanatory variables ESG_{rating_t} and $ESG_{rating} *_t$ are significantly negative. This indicates that, controlling for other variables, the higher the ESG rating, the smaller the pricing efficiency indicator $\mathrm{Efficiency_{r_{it}}}$ of the underlying stock. And the smaller $\mathrm{Efficiency_{r_{it}}}$ means that the forecast price and the actual price error are smaller, making the stock price forecast more accurate and the pricing efficiency higher, thus proving that the higher the ESG stock rating the more accurate the price forecast and the higher the pricing efficiency.

3.2 Data source

The ESG rating data and stock price data used in this article are obtained from the China Economic and Financial Research Database (CSMAR), in addition, there are six times of ESG stock selections, which are from June 2015 to June 2020. Since the performance of different companies varies, there are some enterprises that are rated at time t and not rated at time t+1, this paper selects ESG stocks that are rated at 6 times. Eventually, a total of 113 stocks are ESG-rated stock portfolios. In accordance with common practice, this paper treats non-ESG stocks in the A-share market as follows:(1)exclude companies with missing data;(2)exclude samples with obvious data errors;(3)exclude ST-type stocks;(4)exclude companies that are delisted during the study period.

4 Results

4.1 Descriptive statistic

Table 2. Descriptive statistic [Owner-draw]

	variable	obs	Mean	Median	Min	Max	Std.dev
H1	SMB	50256	0.0012	-0.0003	-0.069	0.0671	0.0029
	HML	50256	0.0063	0.0016	-0.1102	0.1138	0.0416
	Rm	50256	0.0035	0.004	-0.2104	0.1461	0.0581

	Ri	50256	0.0043	-0.006	-0.5269	2.2298	0.1241
	ESG	50256	0.0034	0.0048	-0.0946	0.0807	0.036
H2	SIZE	49558	$3.1010 * 10^7$	$8.7300 * 10^6$	$1.1600 * 10^6$	$2.7860 * 10^9$	$1.0657 * 10^8$
	BM	49558	1.5791	0.8119	0.0318	28.2882	2.6686
	AMRE	49558	0.0016	0.0012	$3.8440 * 10^{-5}$	0.0469	0.0016
	AMREm	49558	0.0011	0.001	0.0008	0.0023	$2.7782 * 10^{-4}$
	MSRE	49558	0.0162	0.0122	0.0001	0.1903	0.0181
	MSRE_m	49558	0.0057	0.0052	0.0042	0.0091	0.0014
H3	SIZE_r	8023	$1.4260 * 10^8$	$6.6180 * 10^7$	$1.8700 * 10^7$	$2.7860 * 10^9$	$2.3350 * 10^8$
	BM_r	8023	3.7834	1.6352	0.072	28.2882	5.3983
	AMRE_r	8023	$1.1070 * 10^{-3}$	$8.637 * 10^{-4}$	$8.9720 * 10^{-5}$	0.0258	0.0012
	AMREm_r	8023	0.0011	0.001	0.0008	0.0023	$2.7783 * 10^{-4}$
	MSRE_r	8023	0.0014	0.0010	0.0001	0.0623	0.0017
	MSREm_r	8023	0.0057	0.0051	0.0042	0.0091	0.0014

Based on the data generated from July 2015 to June 2021 for ESG and non-ESG stocks, Table 2 reports summary statistics of variables that occur in linear regression models (1) (2), and (3). As can be seen from the Table 2, HML (book-to-market ratio factor), Rm (market return), and Ri (individual stock return) in $Hypothesis\ 1$ exhibit greater volatility than the rest of the variables, with standard deviations of 4.115%, 5.806%, and 12.41% respectively, indicating large differences in returns among stocks. The standard deviations of $SIZE$ (total market capitalization of individual stocks) and BM (book-to-market ratio) in $Hypothesis\ 2$ are $1.07 * 10^8$ and 2.6686, respectively, indicating that the selected stock samples have large differences in total market capitalization and book-to-market ratio of individual stocks, ensured the comprehensiveness of the sample. The mean and median of AMRE (individual stock pricing efficiency index) and $AMREm$ (market pricing efficiency index) are close and the standard deviations are small at $1.5731 * 10^{-3}$ and $2.7782 * 10^{-4}$. $MSRE$ (individual stock pricing efficiency indicator) and $MSREm$ (market pricing efficiency indicator) have small standard deviations at 0.0181 and 0.0014, indicating that there only exist small differences in pricing efficiency among stocks. In $Hypothesis\ 3$, large variances occurred in ESG stocks' $size\_r$ and BM_r with standard deviations $2.34 * 10^8$ and 5.3983, indicating large differences in firms' scales. $AMRE\_r$ (individual stock pricing efficiency indicator) and $AMREm\_r$ (market pricing efficiency indicator) both have small standard deviations with $1.1191 * 10^{-3}$ and $2.78 * 10^{-4}$. The standard deviations of $MSREr$ and $MSREm\_r$ at 0.0017 and 0.0014 show that the differences in pricing efficiency indicators among different ESG stocks are small.

Table 3. The results of hypothesis I and II [Owner-draw]

	Panel A: *Hypothesis I*		Panel B: *Hypothesis II* − *AMRE*		Panel C: *Hypothesis II* − *MSRE*	
	coef	P>|t|	coef	P>|t|	coef	P>|t|
$Intercept$	0.0020	$1.61 * 10^{-5}$ ***	$1.398 * 10^{-5}$	0.617	0.0115	0.000 ***
SMB	0.2903	0.000 ***				
HML	0.0742	$3.45 * 10^{-10}$ ***				
Rm	1.0042	0.000 ***				
$Size$			$-1.822 * 10^{-13}$	0.012 **	$2.585 * 10^{-12}$	0.001 ***
BM			$-5.415 * 10^{-5}$	0.000 ***	−0.0005	0.000 ***
ESG_{factor}	-0.7941	0.000 ***				
ESG_{event}			−0.0004	0.000 ***	−0.0166	0.000 ***
$AMRE_m$			1.5408	0.000 ***		
$MSRE_m$					1.4273	0.000 ***
$Observasions$	48855		49558		49600	
$p-value$	0.000		0.000		0.000	

$Hypothesis\ 1$: ESG_{factor} has influence on stock pricing

Table 3, Panel A reports the results for the differences in risk premiums between ESG-rated stocks and nonrated stocks based on equation (1). Our regression results show that the experimental results of the SMB, HML, and Rm factors are consistent with the empirical results of the $Fama-French$ three-factor model, the coefficients of all three factors are positive and significant at 0.1% significance level. This result indicates that SMB, HML, and Rm factors all have positive effects on firm returns and can explain our stock market portfolio returns to a large extent. The regression coefficient of ESG estimator on individual stock risk premium is -0.7941 and is significant at the 0.1% level. It can be concluded that ESG rating can significantly reduce the risk premium of rated stocks relative to unrated stocks, which implies that since ESG ratings represent the disclosure of firms' non-financial performance, as the information disclosed by the firm increases, the risk investing decreases, and the excess return available from the risk simultaneously decreases. Therefore, $Hypothesis\ 1$ holds that whether stocks are rated or not is one of the stock pricing influencing factors, i.e., after controlling for other variables, the prices of the ESG-rated stocks are lower than the unrated ones.

$Hypothesis\ 2$:Being ESG-rated can improve stock pricing efficiency

To verify whether ESG rating or not can affect stock pricing efficiency, this paper formulates $AMRE$ and $MSRE$ of individual stocks based on equation (4) and (5) respectively and regresses them based on equation (6) after summing them into total market portfolio error variables. Panel B reports the results. The coefficients of control

variables $Size$ and BM are both negative and significant at the 5% and 0.1% significance levels, while the coefficient of $AMREm$ is positive and significant at the 0.1% significance level. The regression coefficient of the dummy variable ESG factor is significantly negative at the 0.1% level, implying that the ESG-rated stocks' pricing error decreases after other variables are controlled, i.e., being rated contributes to the efficiency of stock pricing.

In addition, to further reflect larger deviation values, we also calculate the regression results of $MSRE$, Panel C reports the results. The control variable $Size$ has a small positive coefficient and BM has a negative one, both of which are significant at the 0.1% significance level. The estimator, ESG factor regression coefficient, is significantly negative at the 0.1% level. Through comparison, we found that the ESG rating factor still contributes to pricing efficiency after adjusting the pricing efficiency measure.

Table 4. The results of hypothesis III [Owner-draw]

	$AMRE_r$			$MSRE_r$	
$Variable$	$Classification\ (1)$	$Classification\ (2)$	$Variable$	$Classification\ (1)$	$Classification\ (2)$
$SIZE$	$-2.251 * 10^{-13}$ ***	$-2.147 * 10^{-13}$ ***	$SIZE$	$-3.491 * 10^{-13}$ ***	$-3.330 * 10^{-13}$ ***
	(-4.234)	(-4.067)		(-4.254)	(-4.081)
BM	$-3.099 * 10^{-5}$ ***	$-3.2 * 10^{-5}$ ***	BM	$-4.323 * 10^{-5}$ ***	$-4.357 * 10^{-5}$ ***
	(-13.190)	(-13.965)		(-11.9)	(-12.300)
$AMREm_r$	0.9985 **	1.016 ***	$MSREm_r$	$-6.66 * 10^{-3}$	$-2.385 * 10^{-3}$
	(2.995)	(23.806)		(-0.310)	(-0.111)
ESG_{rating_t}	$-1.108 * 10^{-4}$ ***	——	ESG_{rating_t}	$-6.606 * 10^{-5}$ *	——
	(-4.323)			(-1.989)	
$ESG_{rating} *_t$	——	$-2.278 * 10^{-4}$ ***	$ESG_{rating} *_t$	——	$-1.829 * 10^{-4}$ ***
		(-7.261)			(-3.774)
$year$	$-2.065 * 10^{-5}$ **	$-1.718 * 10^{-5}$ *	$year$	$-4.065 * 10^{-5}$ *	$-3.400 * 10^{-5}$ *
	(-2.981)	(-2.487)		(-2.339)	(-1.969)
$Intercept$	0.0419 **	0.0348 *	$Intercept$	0.0837 *	0.0703 *
	(2.995)	(2.500)		(2.380)	(1.991)

$Hypothesis\ 3$:Higher ESG levels have positive influence on stock pricing efficiency

We cluster the stocks of listed companies into two groups based on the ESG ratings of CSMAR, through two kinds of methods refer to the Experiment Design.

In this paper, we first use AMRE and regress it on equation (7) to test whether ESG rating level affects stock pricing efficiency. Table 4 reports the results of $Method\ I$ and $Method\ II$ respectively. The coefficients of the rating factor ESG-rating are all significantly negative, indicating that the higher the ESG rating, the smaller the $AMRE$, and the smaller the error between the actual price and theoretical price, i.e., the higher the stock pricing efficiency. That is, $Hypothesis\ 3$ holds. Furthermore, we also found that the higher the level of ESG-rating, the smaller the $AMRE$ and the more efficient the stock pricing. When $MSRE$ is considered, still, the regression coefficients of ESG-rating are all significantly negative.

Overall, by comparing the experimental results of H1, H2, and H3, we find that the ESG-rating factor is one of the influencing factors of stock pricing efficiency, and the stocks' pricing errors significantly decreased when rated while the pricing efficiency is higher than that of unrated stocks. Among all the rated stocks, the high-rated group has higher price efficiency than the low-rated one. That is, both rating or not and the specific rating level have a significant impact on stock pricing efficiency.

5 Conclusion

This paper analyses and tests the differences in risk premiums between ESG-rated stocks and non-ESG-rated stocks in China's A-share market using a four-factor model based on the ESG ratings and A-share market data of SynTao Green Finance from 2015-2021. The main findings are as follows: First, there is a significant risk premium in China's A-share market, with non-ESG-rated companies having a significantly higher risk premium than ESG-rated companies, and investing in the former requires additional risk compensation. Secondly, ESG-rated companies have lower pricing errors and more efficient stock pricing than non-ESG-rated companies, suggesting that ESG rating or not can influence stock pricing efficiency. Third, when comparing among ESG-rated companies, stocks with higher ESG ratings have smaller pricing errors, representing the smaller the error between the real price and the theoretical price, the more efficient the stock pricing is, i.e. the level of ESG ratings can have an impact on stock pricing efficiency.

The research in this paper shows that ESG-rated companies have more efficient stock pricing, which means that companies with higher ESG ratings can provide investors with more comprehensive and accurate information to help them better assess the value and risk of their stocks. For companies, this may attract more attention from investors, which benefits the company's growth. In addition, it is also of great significance to promote the healthy development of the capital market and protect the interests of investors. Therefore, policymakers should strengthen the regulation and promotion of ESG ratings, promote better fulfillment of social responsibility by enterprises and improve their ESG ratings, thereby improving the efficiency of pricing ESG stocks and further promoting the sustainable development of China's A-share market.

Acknowledgement

Yunhua Huang, Sheng Li and Keyi He contributed equally to this work and should be considered co-first authors.

References

1. An, G.J., Hua, C., Zhang, F.X., Guo, P.Y., Wang, J.X., Gou, M.Y., (2022) Research on the Impact of ESG System on Capital Market under the Goal of Carbon Neutrality: Based on the Comparative Analysis of Different Industries. Finance Theory & Practice

2. Q., Cao, Q., Xu (2019) Research on the construction of financial "environmental, social and governance" (ESG) system. Journal of Financial Regulation, Issue 4
3. F.Z., Zhou, W.Y., Pan, H., Fu (2020) ESG Responsibility Performance of Listed Companies and Institutional Investors' Shareholding Preferences: Empirical Evidence from Chinese A-share Listed Companies. Science Decision
4. J., Li (2021) Research on ESG risk premium and additional income in China's A-share market, Securities Market Herald
5. Zhu, Q., Cui, X.M., Zou T. (2020) Research on the Impact of Environmental Performance on Enterprise Value: Based on the dual considerations of industry concentration and enterprise competitive position, Finance and Economics, Issue 1, 2020, Page 42-49.
6. Wu, M.Y., Zhang, L.R. (2018) Research on executive team characteristics, environmental responsibility and corporate value, East China Economic Management, 2018, No. 2, pp. 122-129.
7. Kim, M.C ,Kim, Y.H. (2014) Corporate social responsibility and shareholder value of restaurant firms , International Journal of Hospitality Management Volume 40, July 2014, Pages 120-129.
8. Wei, H., Yao, Y.Y, Ma, X.K. (2020) Can social responsibility reduce the cost of equity and capital for enterprises? Finance and Economics, No. 6, 2020, pp. 29-36.
9. Li, X.Q., Cao, J.S. (2016) Cost Efficiency Analysis of Chinese Commercial Banks: Based on DEA Model and CAMEL Rating System , Technology Economics, No. 4, 2016, pp. 91-97.
10. Atan, R., Alam, Md. M.,Said, J.,Zamri, M. (2018) The impacts of environmental, social, and governance factors on firm performance: Panel study of Malaysian companies, Management of Environmental Quality Volume 29 Issue 2.
11. Friede,G., Bassen,A., (2015) ESG and financial performance: aggregated evidence from more than 2000 empirical studies , Journal of Sustainable Finance & Investment , Volume 5, 2015 - Issue 4.
12. Li, Z.F., Feng,L.H. , Pan, Z. & Sohail, H.M. (2022) ESG performance and stock prices: evidence from the COVID-19 outbreak in China, Humanities and Social Sciences Communications volume 9.