



Unveiling the timeless potential: A comprehensive analysis of ESG integration in Chinese listed firms

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ABSTRACT

This paper provides a practical guide for integrating Environmental, Social, and Governance (ESG) information into portfolio construction in Chinese listed firms. We analyze panel data from 2015 to 2019, revealing that higher ESG scores correlate with increased stock market returns. We construct an ESG portfolio, identifying strategies that affirm ESG's value. Notably, our enhancement portfolios for both CSI 300 and CSI 500 consistently outperform their benchmarks. Through Brinson attribution analyses, we attribute the excess return primarily to individual stock selection. Our findings underscore the incremental value of incorporating ESG information in stock price explanations.

1. Introduction

The growing significance of Environmental, Social, and Governance (ESG) factors in financial markets is evident, with approximately US\$35.3 trillion of assets under management being invested using sustainable strategies and applying ESG criteria (Global Sustainable Investment Alliance 2018, 2020).¹ Notably, the surge in investor spending on ESG ratings from data providers, increasing from \$200 million to \$500 million between 2014 and 2018, further emphasizes the importance of ESG considerations in investment decisions (Gilbert, 2019). Considering the escalating attention towards ESG performance, listed companies are increasingly focusing on ESG practices, evident through their disclosures and sustainability reports. However, it remains essential to ascertain whether ESG performance truly adds value.

This study aims to address the inconsistency among investors regarding the impact of ESG information on abnormal returns. Two specific questions are posed: First, whether investors recognize, and reward efforts made in ESG-related areas? Second, whether stocks associated with ESG performance exhibit outstanding performance in the stock market? Divergent views persist on how ESG performance influences stock price performance.

One view aligns with the stakeholder's perspective of "doing well by doing good" (Freeman 1984), where ESG efforts by corporations are valued by markets and socially responsible performance is reflected in stock prices. Prior literature explains the positive impact of ESG on stock valuation through factors like cash flow, risk, and cost of capital (Buckingham et al., 2011; Eccles et al., 2014; Eccles et al., 2017; Ghoul et al., 2011; Godfrey et al., 2009; Gregory et al., 2014; Hong & Kacperczyk, 2009; Jo & Na, 2012; Oikonomou et al., 2012).

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¹ <https://www.gsi-alliance.org/>.

However, a contrasting popular view influenced by Milton Friedman (1970) regards ESG efforts as a misuse of shareholders' funds, potentially suppressing stock prices. Key factors supporting this perspective include increased corporation costs and reduced competitive advantages due to ESG activities (Fabrizi et al., 2014).

Empirical evidence on the relationship between ESG initiatives and stock returns has been inconclusive. Some studies suggest ESG performance enhances stock prices (Brammer et al., 2006; Giese et al., 2016; Giese et al., 2019; Johnstone-Louis et al., 2020; Moskowitz, 1972), while others indicate a negative impact (Kim & Verrecchia 1994; Renneboog et al., 2008; Derwall & Koedijk, 2009). Nevertheless, these conclusions are primarily based on samples from developed markets, with limited research on emerging markets like China (Broadstock et al., 2021).²

China's social responsibility investment (SRI) field is emerging, with slow growth in related products. The study seeks to explore the effectiveness of ESG investment concepts in the Chinese market, considering China's unique national conditions and aiming to design an ESG investment framework based on alpha income maximization. As the concept of green development gains traction and ESG integration with A-shares increases, this research seeks to shed light on whether ESG information is effectively priced in China's capital market and whether investors prefer socially responsible stocks for potential excess returns.

The remainder of this study is structured as follows: In Section 2, we delve into the rationale behind ESG investment and present empirical research that highlights the attainment of abnormal returns through ESG strategies. Building upon this foundation, Section 3 devises a comprehensive set of standard investment frameworks geared towards optimizing the impact of ESG investment. Finally, in Section 4, we draw conclusions based on our findings and offer recommendations for advancing ESG investment practices in China.

2. ESG and the stock market returns

In line with socially responsible investment theory, investors consider not only financial returns but also the impact on environmental, ethical, or social change when constructing their portfolios. Non-compliant stocks are excluded, while ESG-compliant stocks become preferred investment targets, thereby influencing investors' decisions (Global Sustainable Investment Alliance, 2020).

ESG (CSR) investment is generally viewed as a positive signal of firm profitability, contributing to a better corporate reputation. Stakeholders perceive social responsibility as a reliable symbol and a means for corporations to exchange high-cost explicit requirements for low-cost implicit charges. Consequently, CSR acts as a reputation insurance, helping companies overcome adverse events through reduced information asymmetry. Short-term stock price increases are significantly stimulated by improvements in ESG scores (Morgan, 2011).

Conversely, ESG initiatives may be utilized by managers to seek personal benefits and entrench their positions. Higher ESG performance may exacerbate internal agency problems. Research by Jiraporn and Chintrakarn (2013) indicates that managers may pursue socially responsible behavior instrumentally to achieve personal interests. Managers use CSR investments to enhance internal control when their power is low, but reduce such investments when their status becomes stable. Additionally, ESG investment may reduce external supervision and lead to inefficient investments (Surroca & Tribo, 2008; Fabrizi et al., 2014). Consequently, higher ESG scores can translate into higher agency costs, hindering the goal of maximizing shareholders' interests.

2.1. Hypothesis development and the baseline model

According to the theory of social contract, corporations and stakeholders maintain a contractual relationship. Corporations, in exchange for resources, should proactively assume social responsibility to foster positive relations with stakeholders (Fombrun, 1996). Improving ESG performance aims to obtain resources and a favorable business environment from stakeholders, creating a "reputation capital" that safeguards against risks and boosts stock prices.

However, it is observed that corporations with strong social responsibility often exhibit higher management entrenchment. This leads to inefficient investments, as managers prioritize satisfying major shareholders and local governments, thereby making ESG investment a "self-profit tool" rather than maximizing shareholder interests (Jiraporn & Chintrakarn, 2013).

To examine these contrasting perspectives, we propose the following research hypotheses:

Hypothesis 1a. ESG performance negatively affects stock market returns.

Hypothesis 1b. ESG performance positively affects stock market returns.

To test H1, we employ equation (1) to assess the impact of corporate social responsibility on stock market returns. Additionally, recognizing the U-shaped or inverted U-shaped relationship reported in previous studies, we incorporate a quadratic term in equation (2) to investigate the higher-order impact. Controlling for fundamental variables like the year, industry, total market value, roe, and leverage, which significantly influence stock prices based on prior research, further enhances our analysis.

$$STR_{i,t} = \beta_0 + \beta_1 CSR_{i,t} + \sum Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

$$STR_{i,t} = \beta_0 + \beta_1 CSR_{i,t} + \beta_2 CSR_{i,t}^2 + \sum Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (2)$$

2.2. Sample composition and data sources

2.2.1. Sample composition and data sources

We source the ESG data from the “Rankings CSR Ratings” database provided by SynTao Green Finance, a prominent third-party data provider specializing in ESG data and green finance advisory (SynTao Green Finance). These data reflect consistent and comprehensive measures of ESG performance, derived from various public sources such as annual reports, sustainability reports, social responsibility reports, environment reports, announcements, and official websites.

The rating framework employed consists of three layers: the primary layer encompasses the Environmental (E), Social (S), and Governance (G) dimensions. Supporting these dimensions, the secondary layer comprises 12 criteria, encompassing environmental management, disclosure, controversies (under E); employee, supply chain, community, product, philanthropy, and social controversies (under S); and business ethics, corporate governance, and governance controversies (under G). Additionally, more than 300 tertiary criteria are integrated from approximately 1000 data points. The scoring methodology involves a combination of core indicators common to all firms and sector-specific indicators tailored to specific companies in each sector.

Financial data for the study are acquired from CSMAR and Wind databases. We collect the stock price information of all Chinese A-share listed companies between 2015 and 2019, coinciding with the period when SynTao Green Finance began providing social responsibility data. To ensure sample consistency, firms are categorized based on the industry classification standard of the China Securities Regulatory Commission in 2012. We exclude companies with negative owner’s equity and further remove financial companies and ST companies due to regulatory constraints. To mitigate the influence of M & A activities, we exclude firms with total assets exceeding five times or less than 0.2 times the previous year’s value. Additionally, we remove companies with less than three years of continuous observation to ensure an adequate data timeframe. To address outliers, all continuous variables are truncated at the 1% and 99% quantiles. After applying the screening procedures described above, our final sample comprises 2801 firm-year observations spanning the years 2015–2019.

2.3. Empirical analysis

The empirical results from Equation (1) and Equation (2) are presented in Table 3. Initially, Equation (1) examines the correlation between ESG performance and stock returns. The findings reveal a statistically significant correlation between annual stock yield and ESG performance in the model without control variables. To account for various factors influencing stock returns, control variables, including Fama-French’s three factors, ROE, and other financial factors, are added to the model. Model 3 demonstrates that even with control variables, social responsibility performance continues to exert a significant positive impact on stock market returns, confirming Hypothesis 1b. However, when quadratic terms are added in Model_2 and Model_4, they do not show a statistically significant effect on stock market returns. Hence, in China’s A-share market, a linear relationship exists between social responsibility performance and stock price, wherein higher social responsibility performance leads to increased stock market returns (see Table 2).

The observed economic reasons behind these results are multifaceted. Corporations with better social responsibility performance often exhibit higher levels of corporate governance. This is manifested in higher cultural conservation and moral standards, lower motivation for management to conceal negative news, and greater transparency in corporate governance (Gelb & Strawser, 2001). Consequently, the likelihood of earnings manipulation is reduced (Kim et al., 2012). From an investor’s perspective, superior ESG performance signifies efficient operation, stable financial standing, and abundant resources, thereby elevating investor expectations of corporate performance and subsequently driving up stock prices.

Additionally, ESG performance is oriented towards all stakeholders, encompassing consumer demand, product quality, corporate financial status, and environmental performance. This signals to stakeholders that the corporation prioritizes interests beyond its own, fostering a positive corporate image as a responsible citizen. The consistent release and reception of such signals by external investors enable the accumulation of “reputation capital.” While reputation capital may not generate direct transactional benefits or increase capital stock, it serves as a mitigating factor when corporations encounter adverse events. Positive corporate citizen image and reputation capital built through social responsibility establish investor confidence in the corporation’s ability to handle challenges and reduce the inclination towards punitive actions, such as massive stock selloffs (Godfrey et al., 2009). Consequently, it is reasonable that companies with better social responsibility performance experience higher market returns.

3. ESG portfolio construction

The foregoing analysis reveals a noteworthy positive correlation between ESG performance and stock market returns. Consequently, the logical approach is to create an ESG portfolio by adopting a long strategy for stocks with higher ESG scores (long portfolio) and a short strategy for stocks with lower ESG scores (short portfolio).

3.1. Long portfolio construction

A Python-based simulated order placement program was developed to backtest the historical performance of the ESG long strategy. The key parameters used in the simulation are as follows:

- a) Backtest Survey Interval: The backtest covers the period from June 30, 2015, to December 31, 2019.

Table 1
Definition of model main variables.

Variable name	Variable symbol	Explanation
Explained variable		
stock yield	STR	Annual stock return rate considering reinvestment of cash dividend
Explanatory variable		
Social responsibility score	ESG	ESG score of SynTao Green Finance
Control variable		
Total market value	Size	Total assets of the company
Return on net assets	ROE	Return on equity, which represents the company's performance
Leverage ratio	Lev	Asset liability ratio
Turnover rate	Turnover	An annual turnover rate of stock
Total market value	MKT	Market value factor in Fama-French three factors
P/E ratio	PB	Share price/net profit
P/B ratio	PE	Share price/book value

Note: This table reports the definition of the main variables used in this research.

Table 2
Descriptive statistics.

Variable Name	Mean	SD	Min	Median	Max	N
STR (%)	0.0426	0.447	-0.633	-0.0416	2.281	2801
ESG	4.057	0.953	2	4	7	2801
Size (CNY billions)	0.0888	0.149	0.0013	0.0252	0.572	2801
ROE (%)	0.0842	0.148	-0.804	0.0924	0.535	2801
Lev (%)	0.522	0.212	0.0623	0.532	0.941	2801
Turnover (%)	1.458	1.354	0.175	1.042	17.51	2801
MKT	0.0438	0.0478	0.0023	0.0256	0.184	2801
PB	2.940	2.938	0.721	1.987	42.68	2801
PE	0.655	1.579	0.0655	0.261	16.21	2801

Note: This table summarizes statistics for the variables used in this research. The definition of variables is seen in Table 1. STR, ROE, Lev, and Turnover are in percentages. ESG, MKT, PB, and PE are dimensionless. Size is in billions of CNY.

- b) Stock Pool: The backtest includes all A-share stocks, with the exclusion of stocks suspended on a single day. Additionally, stocks listed for less than one year are restricted from being bought at the opening price limit and sold at the opening price limit.
- c) Frequency of Position Adjustment: The strategy implements monthly position adjustments, with stock selection occurring on the last trading day of each month. Purchases are executed at the market price on the next trading day.
- d) Transaction Rate: Given the favorable liquidity of most index components, the transaction rate is set at 0.2% for buying and 0.3% for selling (bilateral thousand 5).
- e) Dividend Payout: No investment is made during the month of the dividend payout.

By employing these parameters, the program effectively backtests the ESG long strategy, providing insights into its historical performance over the specified period.

Based on the established criteria, the CSI 300 Index is chosen as the performance benchmark for evaluating ESG performance. Both Table 4 and Fig. 1 demonstrate evident excess returns associated with ESG performance. Notably, the annualized returns for 30 stocks, 50 stocks, and 100 stocks are 4.15%, 3.32%, and 1.09%, respectively, significantly surpassing the annualized return of 0.93% for the CSI 500 Index. While the excess return diminishes with an increasing number of stocks, it consistently outperforms the CSI 300 Index. Remarkably, the ESG long portfolio exhibits superior performance compared to the CSI 300 Index, even during market declines. For instance, in 2016, while the CSI 300 Index declined by 11.28%, the 30-stock long portfolio decreased by only -2.81%, and the 50-stock long portfolio dropped by -3.18%. Similarly, in 2018, when the CSI 300 Index plunged by 25.31%, the 30-stock long portfolio experienced a milder decline of 22.95%, and the 50-stock long portfolio decreased by 22.42%. These results confirm the positive impact of the ESG long portfolio on the CSI 300 Index.

In the face of systemic risk, the reputation insurance fostered by ESG functions as a hedging mechanism, mitigating the impact of external environmental changes on investor sentiment and reducing the risk of stock price decline. Furthermore, the ESG long portfolio outperforms the benchmark even during a rising stock market. For instance, in the bullish market of 2017, while the CSI 300 Index rose by 21.78%, the long portfolio of 30 stocks experienced a higher increase of 24.74%. Similarly, in 2019, with the CSI 300 rising by 36.07%, the 30-stock long portfolio demonstrated a notable gain of 38.59%. These results may be attributed to a favorable ESG score signaling robust corporate resources, which reflect sound operations and corporate governance, thus boosting investor confidence and driving up stock prices.

3.2. Short portfolio construction

In our study, we analyze the impact of ESG scores on stock portfolios in China's A-share market, considering that short-selling is not

Table 3
The Impact of social responsibility on Stock Returns.

	Model (1)	Model (2)	Model (3)	Model (4)
	STR	STR	STR	STR
ESG	0.0210*** (2.94)	0.0609 (1.29)	0.0170*** (2.78)	0.0662 (1.62)
ESG ²		-0.00472 (-0.87)		-0.00584 (-1.23)
Size			-0.0295*** (-2.59)	-0.0298** (-2.56)
ROE			0.328*** (7.15)	0.329*** (7.13)
Lev			0.0598 (1.22)	0.0656 (1.33)
Turnover			0.0294*** (3.47)	0.0295*** (3.47)
MKT			0.594*** (3.33)	0.604*** (3.29)
PB			0.0529*** (7.99)	0.0529*** (7.97)
PE			0.00477*** (4.37)	0.00478*** (4.38)
Constants	0.191 (1.45)	0.109 (0.63)	-0.246*** (-2.62)	-0.351*** (-2.76)
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
N	2801	2801	2801	2801
R ²	0.279	0.278	0.504	0.502

Note: This table reports estimates of Equations (1) and (2) for the sample of China's A-share listed companies from 2015 to 2019. Model_1 and Model_3 report estimates of Equation (1), and Model_2 and Model_4 report estimates of Equation (2). The explained variable is the STR of individual companies. The explanatory variables are ESG and ESG.² Company-level controls are Size, ROE, Lev, Turnover, MKT, PB, and PE. SE are clustered at the bank level and are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. All estimations feature annual fixed effects and industry fixed effects.

² Broadstock et al. (2021) and other studies document the effect of ESG during crisis and show the hedge effect of ESG activities, our studies is different since we our sample is before 2020 and exclude the effect of covid-19 shock for the ESG stock return.

allowed in this market. To investigate this, we create separate portfolios comprising the 30, 50, and 100 stocks with the lowest ESG scores. If the combination of the 50 and 100 stocks falls below the CSI 300 Index, it indicates a negative elimination effect. Table 5 and Fig. 2 present the findings, revealing annual returns of -8.61%, -5.86%, and -6.93% for the combined 30, 50, and 100 stock portfolios, respectively, which are significantly lower than the CSI 300 Index (see Table 6 and Table 7).

During bullish market periods, such as 2017 and 2019, we observe that stocks with lower ESG scores fail to demonstrate substantial price increases. For instance, the return rate for the 30-stock portfolio was only 8.11% in 2017 and 17.67% in 2019. This phenomenon could be attributed to investor concerns about the operational status and corporate governance practices of companies with lower ESG scores. As a result, even in favorable market sentiments, the stock price appreciation of such companies remains limited.

3.3. Index enhancement strategy

The above analysis demonstrates the informative value of both long and short ESG portfolios for portfolio construction. Given the constraints in the Chinese A-share market, where short selling is not possible, the portfolio optimization approach involves over-weighting stocks with higher ESG scores and underweighting those with lower ESG scores in the index enhancement model.

(1) IC value analysis

To assess how ESG influences future stock returns from a factor investment perspective, we employ IC value analysis. In portfolio analysis, IC value analysis, also known as Information Coefficient (IC) value analysis, evaluates the accuracy or predictive power of investment signals or strategies in quantitative finance and portfolio management. The factor IC and Rank_IC values are calculated as the Pearson and Spearman correlation coefficients between the factor values and the cumulative upside and downside for the subsequent month (for detailed IC calculation process, refer to Appendix B).

As depicted in Fig. 3, the ESG factor demonstrates remarkable effectiveness in the Chinese A-share market, as evidenced by mean values of IC and Rank_IC at 3.34% and 4.05%, respectively. To assess the robustness of the cumulative IC curve, we calculate ICIR and Rank_ICIR by dividing the mean IC value by the standard deviation. The results reveal annualized ICIR and Rank_ICIR of 1.52 and 1.80,

Table 4
ESG long portfolio earnings performance.

	CSI 300	30 stocks	50 stocks	100 stocks
2015	−16.59%	−16.83%	−17.01%	−16.38%
2016	−11.28%	−2.81%	−3.18%	−4.96%
2017	21.78%	24.74%	25.56%	18.44%
2018	−25.31%	−22.95%	−22.42%	−22.53%
2019	36.07%	38.59%	33.64%	30.89%
Annualized income	0.93%	4.15%	3.32%	1.09%

Note: This table reports the backtest result of the historical performance of the ESG long strategy of a simulated order placement program written in Python.



Fig. 1. ESG long portfolio net worth performance.

respectively. These outcomes firmly establish the social responsibility factor’s substantial stock selection effect across all A-shares. Notably, companies contributing more significantly to social responsibility witness enhanced stock price performance, underscoring the positive relationship between social responsibility efforts and stock performance.

Figs. 4 and 5 assess the stock selection effect of ESG factors in the CSI 300 and CSI 500 constituents, respectively. The results presented in Fig. 12 illustrate that the IC cumulative curve remains upward, but the correlation between IC values and stock returns weakens after 2018. Subsequently, the cumulative curve exhibits a gradual flattening trend, reaching IC values and ICIR values of 0.88, respectively. On the other hand, the IC cumulative curve for CSI 500 component stocks remains stable, with an IC average of 3.7% and an ICIR of 1.78. These divergent outcomes suggest that ESG factor utilization in the CSI 300 constituents lags behind that in the CSI 500 constituents in terms of stock selection. This disparity may be attributed to the higher proportion of state-owned corporations and financial companies within the CSI 300, actively fulfilling their social responsibility obligations. In contrast, the CSI 500 constituents demonstrate more balanced corporate ownership and industry distribution, making their social responsibility performance more valuable for external investors when making investment decisions.

(2) Index-enhanced portfolio construction

Building upon the findings of the previous study, which identified stock selection effects based on social responsibility performance within the constituents of CSI 300 and CSI 500, this section extends the analysis by integrating this factor into an index enhancement model.

The index enhancement problem is formulated as a mean-variance model, aiming to maximize the exposure to ESG scores while calculating the covariance matrix using the Ledoit-Wolf method.

$$\begin{aligned}
 &\max r^T \omega - \frac{1}{2} \lambda \omega^T \Sigma \omega \\
 &\text{s.t. } (\omega^T - \omega_{Bench}^T) Size = 0 \\
 &(\omega^T - \omega_{Bench}^T) Ind = 0 \\
 &\omega_i > 0 \\
 &\sum \omega_i = 1
 \end{aligned}$$

Table 5
ESG short portfolio earnings performance.

	CSI 300	30 stocks	50 stocks	100 stocks
2015	-16.59%	-18.56%	-13.79%	-14.24%
2016	-11.28%	-16.66%	-15.81%	-13.63%
2017	21.78%	8.11%	9.57%	4.14%
2018	-25.31%	-33.62%	-27.76%	-30.30%
2019	36.07%	17.67%	18.52%	19.37%
Annualized income	0.93%	-8.61%	-5.86%	-6.93%

Note: This table reports the back-testing result of the historical performance of the ESG short strategy of a simulated order placement program written in Python.

Table 6
Returns of ESG-based CSI 300 index enhancement strategy.

	Strategy Benefits	Maximum retracement	Benchmark income	Hedging income	Hedging retracements	Hedging retracement days
2015	-13.50%	-30.05%	-16.59%	3.09%	-3.35%	27
2016	-9.64%	-21.68%	-11.28%	1.64%	-3.80%	32
2017	22.65%	-7.10%	21.78%	0.87%	-3.08%	38
2018	-22.08%	-29.03%	-25.31%	3.23%	-3.08%	48
2019	35.06%	-13.06%	36.07%	-1.01%	-2.86%	134
Annualized Yield	2.50%	-20.18%	0.93%	1.56%	-3.23%	55.8

Note: This table reports the back test result of the historical performance of the ESG-based CSI 300 Index Enhancement Strategy of a simulated order placement program written in Python. The benchmark is CSI 300 Index.

Table 7
Returns of ESG-based CSI 500 index enhancement strategy.

	Strategy Benefits	Maximum retracement	Benchmark income	Hedging income	Hedging retracements	Hedging retracement days
2015	-6.51%	-35.91%	-14.47%	7.96%	-4.44%	7
2016	-3.99%	-24.16%	-17.78%	13.79%	-1.93%	24
2017	-1.46%	-13.72%	-0.20%	-1.26%	-5.99%	96
2018	-28.62%	-35.79%	-33.32%	4.70%	-3.37%	25
2019	32.97%	-20.71%	26.38%	6.59%	-3.23%	9
Annualized Yield	-1.52%	-26.06%	-7.88%	6.36%	-3.79%	32.2

Note: This table reports the backtest result of the historical performance of the ESG-based CSI 500 Index Enhancement Strategy of a simulated order placement program written in Python. The benchmark is CSI 500 Index.

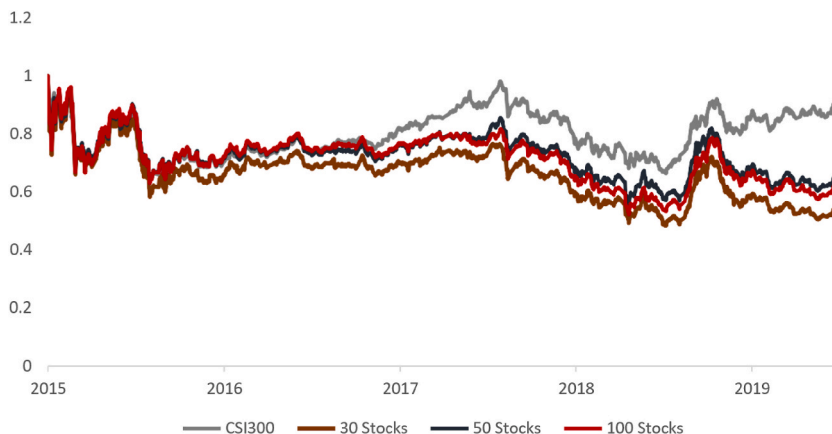


Fig. 2. ESG short portfolio net performance.

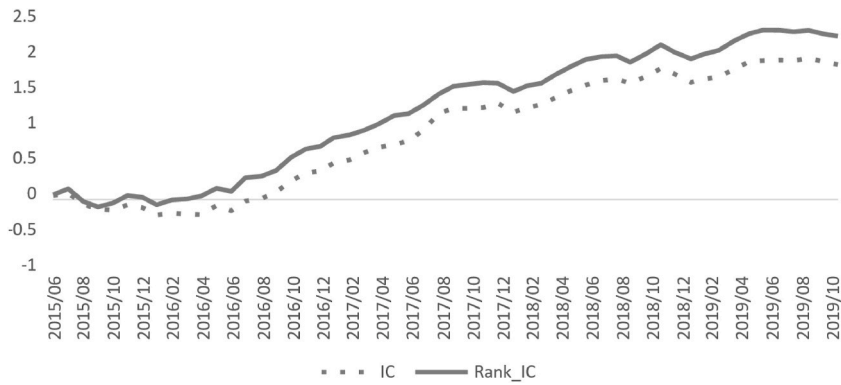


Fig. 3. Cumulative curve of ESG factor IC for A-share listed companies.

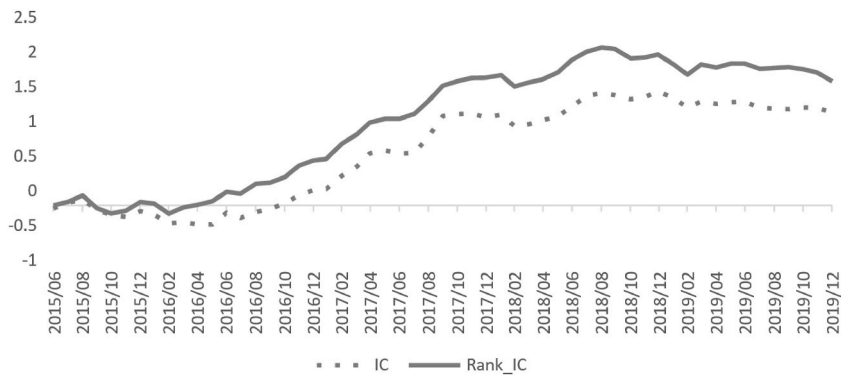


Fig. 4. Cumulative curve of ESG Factor IC in CSI 300 constituents.

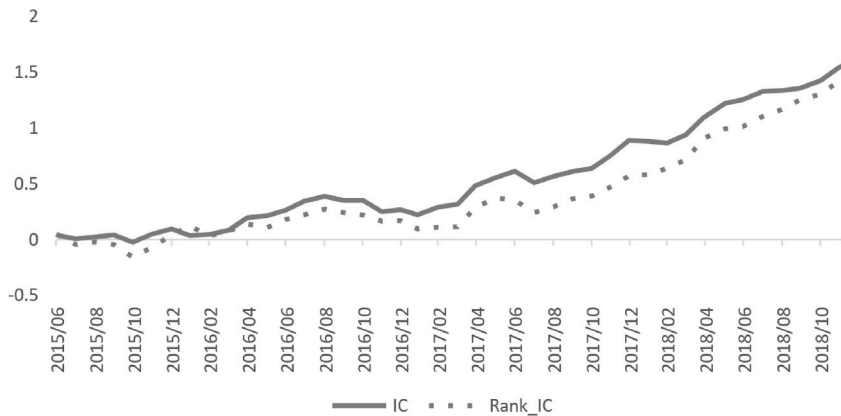


Fig. 5. IC accumulation curve of ESG factors in CSI 500 constituents.

$$\omega^T \text{Con} = 0.8$$

Of which, ω is the stock weight, Σ is the stock covariance matrix, Size is the stock exposure on market capitalization, Ind is the stock exposure on the industry, Fk is the stock exposure on the style factor, and Con is the dummy variable matrix of whether it is a CSI 300 constituent. The objective function of this optimization problem is to maximize the portfolio’s risk- and cost-adjusted return, which consists of two components: the return term, and the risk term.

$r^T \omega$ is the expected portfolio return, and r is the expected stock return; $\omega^T \Sigma \omega$ is portfolio risk and Σ is the stock return covariance matrix; and λ is the risk aversion coefficient, which determines the risk-return tradeoff.

The constraints include constraints on the portfolio’s market capitalization exposure, sector distribution, style factor exposure, and

individual equity weight.

The first constraint limits the target portfolio’s market capitalization exposure to the benchmark, where the portfolio is set to have plus or minus 1 percentage point exposure to the benchmark in terms of market capitalization; The second constraint limits the target portfolio’s sector exposure to the benchmark, where the portfolio is set to have plus or minus 1 percentage point exposure to the benchmark in terms of the sector; The fourth constraint limits whether the portfolio can be shorted. Since there is no effective shorting tool in the Chinese A-share market, the target weight is set to be greater than 0, that is, it can only be long stocks; The fifth constraint limits the target portfolio weight, which is limited to 1; The sixth constraint limits the target portfolio component share, where the component share is set to be greater than 80%.

From the input variables of the optimization model, the expected stock return and the stock return covariance need to be estimated.

(1) Estimated stock return

The expected return of a stock can be calculated based on the factor exposure as well as the expected factor return, and the historical average of the factor return is usually used as an estimate of the expected factor return. And to reflect the recent changes in factor returns as quickly as possible, this paper uses half-decay weighting to estimate expected factor returns.

(2) Estimated stock return covariance

Regarding the estimation of portfolio risk, when stock idiosyncratic returns are not correlated with the public factor, the expected risk can be decomposed into the risk explained by the public factor and the idiosyncratic risk, where the public factor risk is estimated using the covariance matrix of daily factor returns and the factor exposure, and the idiosyncratic risk is estimated using the volatility of individual stock idiosyncratic returns, that is:

$$\Sigma = XFX^T + \Delta$$

Of which, Σ denotes the covariance matrix of stock returns, F denotes the covariance matrix of factors, X denotes the stock factor exposure matrix, and Δ denotes the idiosyncratic return variance matrix. The model uses the volatility bias statistic as a measure of risk prediction accuracy and performs multi-step corrections to the factor return covariance matrix and the idiosyncratic return variance matrix, respectively, to effectively improve the accuracy of risk estimation and thus provide accurate and reliable risk prediction.

From the results in Figs. 6 and 7, it can be seen that through an optimized approach, notable enhancements can be achieved using socially responsible performance scores. Among them, the CSI 300 index enhancement strategy based on ESG factors can achieve an annualized excess return of 1.56% and maximum hedge net retracement by only -3.23%; while in the CSI 500 index enhancement strategy, relative to the performance comparison benchmark, it can achieve an annualized 6.36% excess return and the maximum hedge net retracement is only -3.79%.

(3) Brinson attribution and revenue decomposition analysis

Brinson Attribution is a performance attribution analysis technique used to decompose the returns of an investment portfolio. The Brinson model breaks down the portfolio’s return into three components: asset allocation effect, security selection effect, and interaction effect. It helps investors and portfolio managers understand how different investment decisions contributed to the overall performance of the portfolio.

Using the Brinson model (see Appendix C for details of the calculation process) to decompose the excess returns of the ESG-based CSI 500 enhanced model, it can be seen from Fig. 8 that the portfolio has essentially no excess returns on sector allocation due to the restricted sector neutrality, and almost all of the excess returns originate from stock selection, thus further demonstrating the

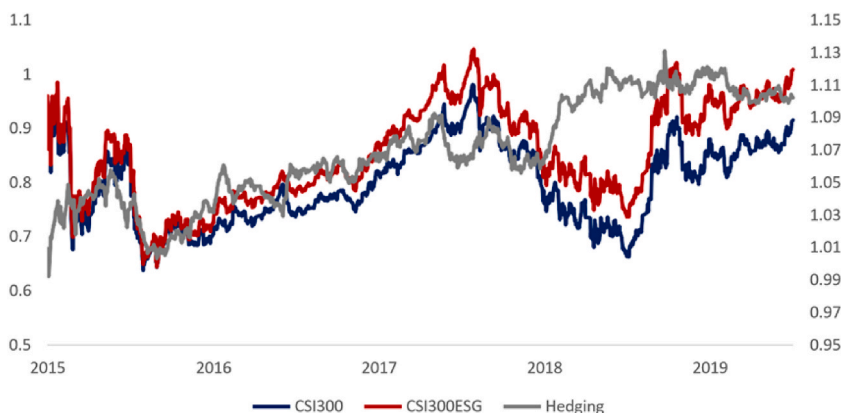


Fig. 6. Performance of CSI 300 index enhancement strategy based on social responsibility performance.



Fig. 7. CSI 500 enhanced strategy net based on socially responsible performance.

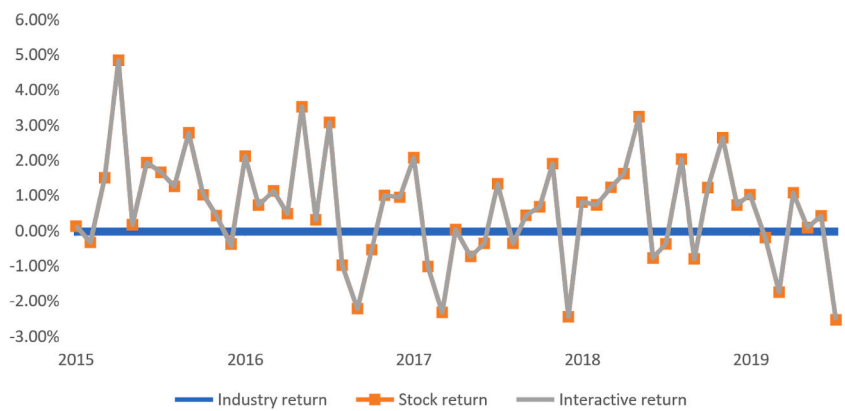


Fig. 8. Brinson decomposition of ESG-based CSI 500 index enhancement strategy.

effectiveness of the portfolio optimization model above.

(4) Factor model return decomposition

Concerning the Barra factor model, a factor return decomposition model was constructed (see Appendix D for details of the calculation process), and 10 style factors were included in the style factor as the strategy controlled for sector neutrality, and further decomposition was performed using the factor model excess return sources. As can be seen in Fig. 9, in 2015, when market volatility was more intense, most of the portfolio excess returns originated from the style factor, and as market volatility decreases, the excess

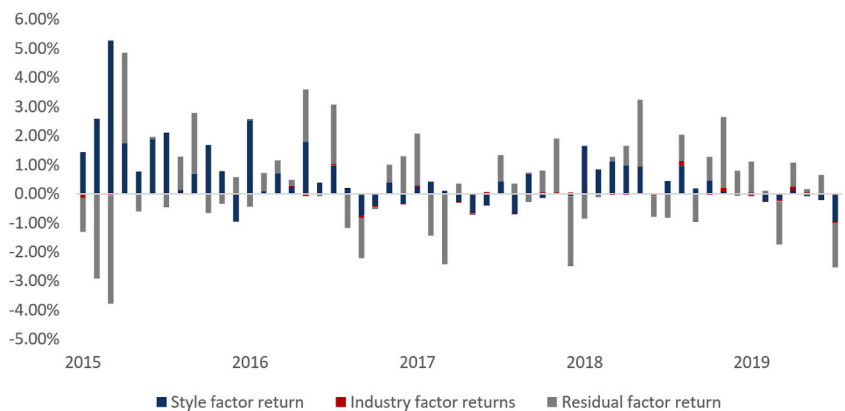


Fig. 9. Factor decomposition of ESG-based CSI 500 index enhancement strategy.

returns come more from the incremental information of the ESG model itself. The above results show that although most of the excess returns of the ESG model can be explained by the existing style factors, there is still a significant proportion of incremental information that can improve the portfolio returns.

Further decomposition of the excess returns brought by the style factor shows that the excess returns of the strategy mainly originate from the dimensions of Trend, Cubic size, and Value, as can be seen in Fig. 10. The implied logic behind it may be that: First, stocks with better ESG performance send signals to investors that the company is in good operating condition and has a high level of corporate governance, and it is easy to form a long-term uptrend, once starting the stock price; Second, the Cubic size factor increases the weight of large-cap and small-cap stocks, indicating that the ESG factor is less effective in mid-cap stocks; Third, the Value factor also brings an excess return of 4.65%, so from the style point of view, the ESG strategy’s stock selection is biased towards value, and the growth of stocks is relatively average.

3.4. Multi-objective optimization strategy

ESG investments have demonstrated a positive impact on the environment, society, and corporate behavior while also yielding favorable investment returns. However, it is important to note that excessive adherence to ESG investment principles may restrict the range of available investment options, potentially overlooking profitable opportunities and affecting investment returns. Conversely, some scholars argue that companies with strong social and market reputations can earn trust over time.

Traditional portfolios emphasize return and risk (volatility), seeking to maximize return while minimizing risk. In contrast, ESG investment integrates a third dimension: ESG quality. The objective is to achieve high returns, low volatility, and high portfolio quality. Balancing high returns with low volatility presents a complex challenge, especially when considering the incorporation of ESG factors.

In a traditional mean-variance portfolio model, investors aim to attain the minimum risk for a given expected rate of return or the maximum expected return for a given risk. This creates a two-objective optimization problem. Fig. 11 illustrates the effective frontier surface of the mean-variance model, with detailed mathematical expressions provided below.

$$\begin{aligned} \max E(r_t) &= \sum \omega_i r_i \\ \min \sigma^2(r_t) &= \sum \sum \omega_i \omega_j \text{cov}(r_i, r_j) \\ \text{s.t. } \sum \omega_i &= 1 \\ 0 < \omega_i < 1 \end{aligned}$$

However, the model presented above solely examines stock selection based on maximizing ESG and minimizing risk, without incorporating an assessment of investment return. To address this, we seek to construct a comprehensive model that considers the integration of return, risk, and ESG quality. The mathematical representation of this investment concept involves adding ESG optimization objectives to the mean-variance two-objective optimization, resulting in the formulation of a mean-variance-ESG three-objective optimization model. The mathematical expression for the equity portfolio, aimed at simultaneously maximizing return, minimizing risk, and maximizing ESG score, is depicted below.

$$\begin{aligned} \max E(r_t) &= \sum \omega_i r_i \\ \min \sigma^2(r_t) &= \sum \sum \omega_i \omega_j \text{cov}(r_i, r_j) \\ \max E(ESG_t) &= \sum \omega_i ESG_i \\ \text{s.t. } \sum \omega_i &= 1 \\ 0 < \omega_i < 1 \end{aligned}$$

When introducing the ESG objective function, each ESG constraint value corresponds to a mean-variance efficient frontier curve, as depicted in Fig. 12. The optimal solution set of the tri-objective optimization problem is formed by multiple mean-variance efficient frontier curves under various ESG constraints. Notably, solutions on the efficient frontier surface cannot be further compared in terms of their advantages and disadvantages.

Consequently, we reexamine the variation of portfolio objective function values from three distinct two-dimensional perspectives. Firstly, from the ESG standpoint, a higher ESG level results in increased portfolio variance and decreased portfolio return. Secondly, in terms of self-return, higher returns lead to higher variance and lower ESG scores in the portfolio. Thirdly, from the risk perspective, a higher willingness to take risks corresponds to increased ESG levels and portfolio returns.

Considering the efficient frontier surface, selecting the upper-left region is suitable when prioritizing high returns, the lower-left region is favored when emphasizing low risk, and the lower-right region is chosen when placing a higher importance on ESG. By bounding returns and ESG performance with constraints, the target portfolio can be constructed as close to the upper-right corner as

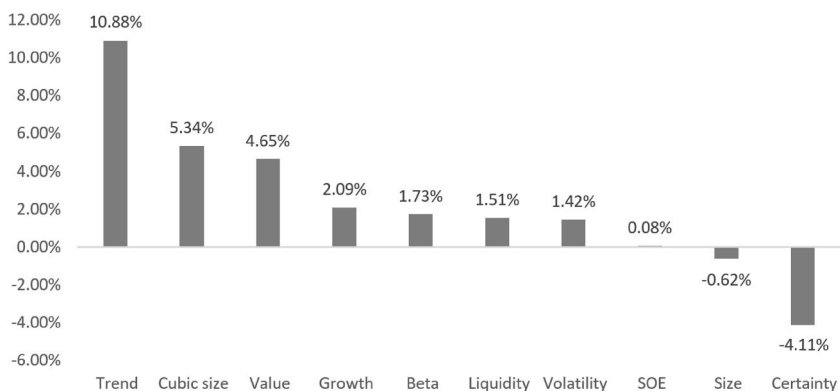


Fig. 10. ESG-based return decomposition of CSI 500 enhanced strategy style factors.

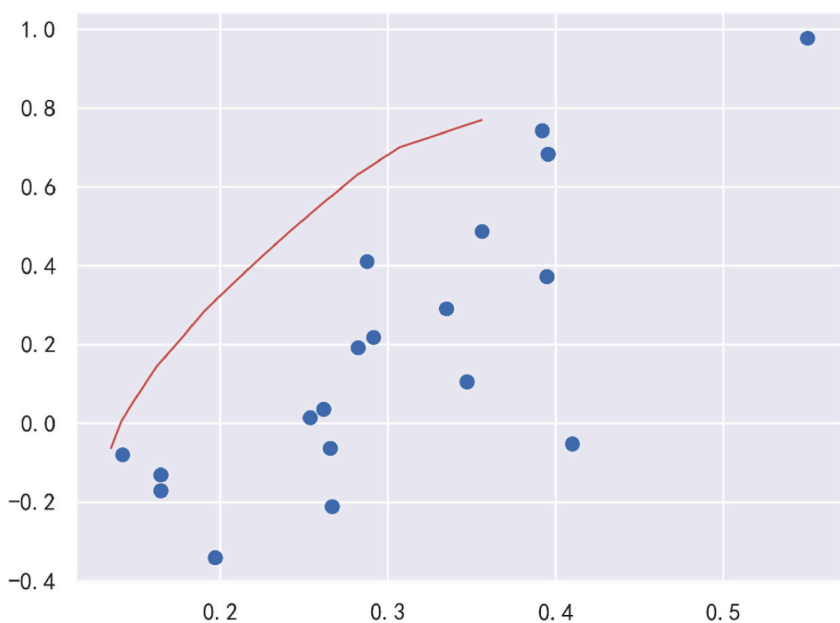


Fig. 11. Efficient frontier based on mean-variance model.

possible by minimizing risk. Specifically, the objective is to have portfolio returns and ESG scores surpassing those of the benchmark index. To achieve this, two constraints are added to the model:

- 1) Aiming for a high portfolio return that exceeds the 90th percentile of the expected return of the benchmark index constituents.
- 2) Striving for a high portfolio weighted ESG score that surpasses the 90th percentile of the ESG score of the benchmark index constituents.

Based on the findings presented in Figs. 13 and 14, the mean-variance-ESG-based model demonstrated significant stock selection effects. While the mean-variance model, enhanced by incorporating ESG factors, did not exhibit pronounced improvements in the CSI 300 index, the results align with previous research outcomes. Conversely, the model displayed favorable predictive effects in the CSI 500 index, with the cumulative curve of excess returns exhibiting greater stability compared to the portfolio optimization model. However, it is important to note that some retracement occurred since 2019.

4. Conclusions and recommendations

4.1. Research conclusions

This study examines the influence of ESG performance on portfolio diversification and risk in the Chinese A-share market, leading

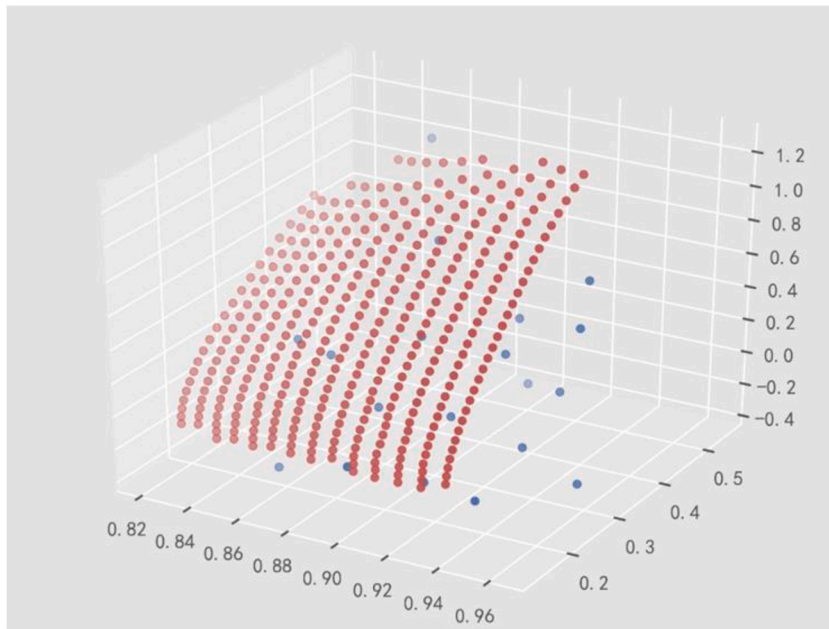


Fig. 12. Efficient frontier based on mean-variance-ESG model.



Fig. 13. CSI 300 enhancement strategy based on mean-variance-ESG model.

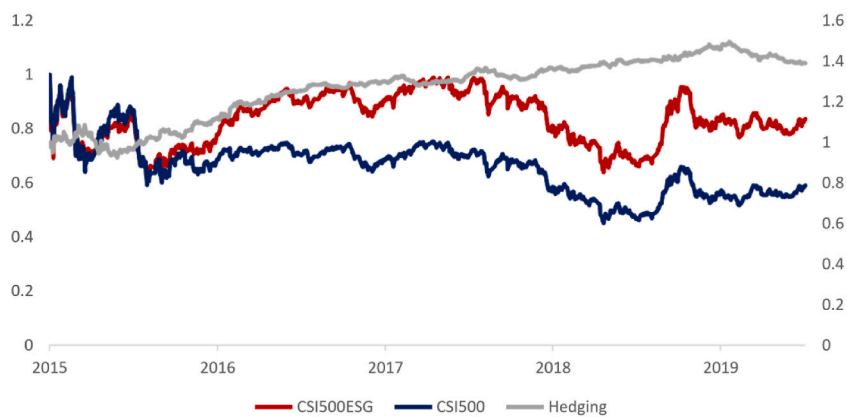


Fig. 14. CSI 500 enhancement strategy based on mean-variance-ESG Model.

to the following key findings:

Firstly, we investigate the impact of ESG performance on stock returns in the A-share market, with a focus on the pre-Covid-19 period to mitigate pandemic-related fluctuations. Our analysis reaffirms that ESG performance significantly and positively affects stock market returns in the Chinese A-share market. Remarkably, we identify that the trend of ESG investing, which enhances investors' returns, was already evident before the Covid-19 outbreak. The potential mechanism underlying this impact is that companies with better ESG practices may experience lower agency costs and a heightened reputation, thus acting as an insurance mechanism that boosts stock returns even during downturns.

Secondly, we construct an ESG-based portfolio, and our findings validate the notion that ESG information adds value by providing investors with potential excess returns. Both long and short ESG strategies yield consistent results, supporting the integration of ESG criteria for investment decisions. Notably, the ESG-based CSI 500 index enhancement model demonstrates steady outperformance compared to the benchmark index. By employing factor return decomposition, we identify that a substantial portion of the model's excess returns can be attributed to the style factor. Nevertheless, there are unexplained components that contain additional valuable information beyond the traditional factors.

In conclusion, our research underscores the significant influence of ESG performance on stock returns and confirms the value of ESG information in constructing portfolios with enhanced returns. The evidence supports the notion that ESG integration provides investors with an additional edge and reveals the potential benefits of incorporating ESG criteria into investment strategies within the Chinese A-share market.

4.2. Policy recommendations

In light of our paper's findings, we propose that the government adopts a "bottom-up approach" in addition to the prevailing "top-down" strategy in promoting corporate Environmental, Social, and Governance (ESG) initiatives. Presently, the Chinese government focuses on implementing a "top-down" approach, using laws and regulations to encourage corporate social responsibility. However, due to the unique institutional environment and the transitional phase of economic development, the social consciousness of corporate managers may not be as robust as in developed countries.

As sustainable economic and social development progresses, it becomes imperative for corporations to strike a balance between shareholder interests and stakeholder concerns. To achieve this, investors and corporate managers should be encouraged through public awareness campaigns to pay greater attention to Corporate Social Responsibility (CSR) information. Investors, in particular, should consider CSR performance when making investment decisions. Our study provides evidence on how ESG initiatives contribute to maintaining both social and investor relationships. ESG values have gained global popularity, especially in China, where they can be effectively integrated into the stock market. Encouraging corporations to actively take social responsibility and ESG initiatives will not only strengthen social relationships but also foster stronger investor relationships.

Secondly, we recommend that the government actively support and nurture the socially responsible investment market. Despite the significant disparity between the number and size of socially responsible funds in China compared to developed countries, our research reveals that social responsibility can enhance portfolio returns in the Chinese A-share market. As the A-share market is primarily retail-driven and relatively immature, government intervention becomes pivotal in promoting socially responsible investment. Facilitating collaboration between individual and institutional investors and CSR and directing funds towards companies with exemplary social responsibility performance, will serve as a crucial reference for the nascent development of socially responsible investment in China.

Thirdly, we propose that the government takes measures to enhance the standardization and breadth of social responsibility report disclosure. Our study demonstrates that the market values ESG information, making the quality of such information paramount. While corporations have been required to voluntarily disclose social responsibility reports since 2009, the varying quality of these reports weakens their communication role. To address this, we suggest involving third-party institutions to appraise social responsibility reports, altering regulatory perspectives, and improving the credibility of CSR reports through standardized third-party institutions and an enhanced appraisal and supervision mechanism.

By considering these recommendations, the government can harness the full potential of ESG integration and social responsibility in enhancing sustainable economic growth and development in China.

Compliance with ethical standards

- i. Disclosure of potential conflicts of interest
- ii. Research involving Human Participants and/or Animals (If applicable)
- iii. Informed consent (If applicable)

CRedit author statement

Ting Wang: Conceptualization, Software, Visualization, Investigation, Writing- Original draft preparation, Validation.

Huaxi Zhang: Conceptualization, Methodology, Data curation, Visualization, Formal analysis, Writing- Reviewing and Editing.

Data availability statement

The data is confidential and from a commercial source.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.iref.2024.03.057>.

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