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Are ESG Factors Effective Asset Pricing Factors in China's A-share Market

——An empirical analysis based on the Fama-French five factor model

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Abstract: In all asset pricing literature at home and abroad, it is a common pursuit of scholars to devote themselves to finding more effective factors. In recent years, along with the increasing prominence of global environmental and social issues, the focus of China's policy has shifted from the pursuit of economic growth to sustainable development, and the concept of responsible investment has quietly gained popularity. We hypothesize that ESG factors have become a non-negligible factor in asset pricing. Therefore, this paper introduces ESG factors based on Fama's five-factor model and constructs the FF5+ESG six-factor model, focusing on analyzing the pricing efficiency of ESG factors to provide the latest empirical evidence for China's asset pricing model.

Keywords: Asset Pricing, Fama-French Factor Model, ESG

1. Introduction

Financial academics have been studying asset pricing factors for more than eighty years, and CAPM and APT theories provide theoretical benchmarks for studying the factors, while Fama & French's study not only proposes a systematic method for testing capital asset pricing theory, but also proposes a succinct empirical capital asset pricing model. However, whether it is a three-factor or five-factor model, the factor models at home and abroad cannot fully explain the various pricing imagery in the capital market. Therefore, searching for various anomalies or potential factors and proposing better pricing models have become the current frontier direction in the field of empirical asset pricing.

In recent years, with the rapid development of the ESG concept in the world, ESG-related policies have gradually been included in China's policy priorities. 2020, at the Paris Climate Change Conference, China signed the Paris Agreement, which put forward the "dual-carbon" goal of reaching the carbon peak by 2030 and achieving carbon neutrality by 2060. 2022, the 20th Party Congress of the People's Republic of China (PRC) will be held in Beijing. In 2022, the 20th Party Congress of China will be held in Beijing, and many of the topics will be highly compatible with the connotation of ESG. Against this policy backdrop, ESG concepts are gaining more and more attention and support from investors in China. Therefore, it is imperative to deepen the analysis of the effectiveness of capital asset pricing factors and explore the deep connection between ESG performance and excess return.

2. Data and methods

2.1 Sample Selection and Data Sources

Considering the comprehensiveness of ESG data, this paper selects the monthly data of A-share listed companies for a total of 132 months from January 2012 to December 2022 as the sample. Consistent with most academic literature, the risk-free interest rate in this paper adopts the RMB one-year whole deposit and withdrawal rate published by the People's Bank of China, the individual stock return adopts the monthly return in the database considering the reinvestment of cash dividends, and the market return is selected as the consolidated monthly market return considering the reinvestment of cash dividends. The financial data in this article are all from the database of Cathay Pacific.

Referring to Liu's (2019) article, the data are processed as follows:(1) financial companies are excluded (2) missing values, ST, and PT categories are excluded (3) stocks with negative book value are removed (4) market capitalization weights of stocks are calculated using outstanding share capital (5) for the IPO phenomenon, it is generally believed that new stock listings are accompanied by underpricing and

low stock price performance after the listing (Yu Zengbiao, and Liang Wentao. 2004), in order to eliminate the influence of abnormal price behaviour of newly listed stocks on the results, this paper excludes the trading data of all stocks within six months after listing (including the listing month); (6) The financial data of all listed companies are from the consolidated statements.

ESG scores are obtained from Shanghai CSI Index Information Service Co., Ltd., and this paper uses Python to crawl the composite ESG scores issued by CSI on October 31 every year to measure the ESG performance of listed companies.

2.2 FF5+ESG six-factor model construction

In order to investigate whether ESG ratings of Chinese enterprises can bring better stock returns, ESG rating factors are introduced based on the Fama-French five-factor model (1) to construct the Fama-French 5+ESG six-factor model:

$$Rit - Rft = \alpha i + \beta i (Rmt - Rft) + si\ SMBt + hi\ HMIt + ri\ RMWt + ci\ CMAt + \varepsilon it \quad (1)$$

$$Rit - Rft = \alpha i + \beta i (Rmt - Rft) + si\ SMBt + hi\ HMIt + ri\ RMWt + ci\ CMAt + di\ ESGt + \varepsilon it \quad (2)$$

Where Rit denotes the individual stock return in period t; Rmt denotes the market return in period t; Rft denotes the risk-free rate of return; Rit -Rft denotes the individual stock risk premium in period t; Rmt -Rft denotes the market risk premium factor in period t; SMB denotes the market capitalization factor; HML denotes the book-to-market ratio factor; RMW denotes the profitability factor; CMA denotes the investment model factor; ESG denotes the ESG factor, which refers to the difference between the returns of stock portfolios with high ESG scores (Good) and low ESG scores (Bad). (If the rating factor is positive, it indicates that firms with higher ESG ratings generate higher stock returns) βi、si、hi、ri、ci、di denotes the FF5+ESG factor coefficients, and the αi regression intercept term should be zero if all six factors explain all of the individual stock excess returns.

2.2.1 Portfolio segmentation

The 2×3 grouping method of Fama and French (2015) is used, based on data availability for investors, for all stocks from July t - June t+1, as follows:

(i) Classification of market capitalization portfolios:

By the median market capitalization outstanding at the end of June in year t, all stocks are divided into two groups from high to low (excluding stocks with market capitalization of zero), with those larger than the median in the large-cap group (B) and those smaller than the median in the small-cap group (S).

(ii) Classification of book-to-market (B/M) ratio portfolios

All stocks are ranked from high to low according to their book-to-market ratio (book value/market capitalization outstanding) at the end of year t-1. Stocks located in the top 30% (including 30%, the same below) are in the high book-to-market ratio group (H), stocks located in the 30% to 70% range are in the medium book-to-market ratio group (N), and stocks located in the bottom 30% are in the low book-to-market ratio group (L).

The market capitalization and book-to-market ratio indicators were crossed to categorize all stocks into six groups: SH, SN, SL, BH, BN, and BL;

(iii) Classification of profitability (OP) portfolios

Operating profit/owner's equity at the end of year t-1 is chosen as a measure of corporate profitability, and the entire stock is ranked from high to low by this value, with the top 30% being the high profitability group (R), the 30%-70% being the middle group (N), and the bottom 30% being the low profitability group (W).

Crossing market capitalization and profitability metrics divides the entire stock into six groups: SR, SN, SW, BR, BN, and BW;

(iv) Segmentation of the investment model (INV) portfolio

(Total assets at the end of year t-1 - total assets at the end of year t-2)/t-2 total assets at the end of year t-2 is chosen as a measure of the firm's investment pattern, and the entire stock is ranked from high to low by this value, with the top 30% being the Aggressive group (A), the 30%-70% being the Middle group (N), and the bottom 30% being the Conservative group (C).

Crossing market capitalization and investment pattern indicators, the total stocks were categorized into six groups: SC, SN, SA, BC,

BN, and BA;

(v) Classification of ESG performance (ESG) portfolios

The CSI ESG score data at the end of year t-1 is selected as the corporate ESG performance measure, and the 30% and 70% quartiles are used to divide all stocks: the top 30% is the high-scoring group (G), 30%-70% is the middle group (N), and the bottom 30% is the low scoring group (D).

A crosswalk of market capitalization and ESG scoring metrics was used to categorize all stocks into six groups: SG, SN, SD, BG, BN, and BD.

Table 1 Monthly Returns, Market Capitalization, Book-to-Market Ratio, Profitability, Investment Model, and ESG Score Data Time Correspondence Points

monthly yield	market value	Book-to-market ratio	profitability	Investment model	ESG score
July 2017-June 2018	End of June 2017	End of 2016	End of 2016	End of 2016	End of 2016
July 2018-June 2019	End of June 2018	End of 2017	End of 2017	End of 2017	End of 2017
July 2019-June 2020	End of June 2019	End of 2018	End of 2018	End of 2018	End of 2018
July 2020-June 2021	End of June 2020	End of 2019	End of 2019	End of 2019	End of 2019
July 2021-June 2022	End of June 2021	End of 2020	End of 2020	End of 2020	End of 2020

According to the literature by Fama and French (2015), other indicators such as book-to-market ratio, investment, and earnings can be better controlled for market capitalization effects associated with these factors by crossing them with market capitalization indicators, thus ensuring that the effects of each factor are independent.

2.2.2 Factorization

All stocks are divided as described above, and 24 asset portfolios are formed yearly.SH, SN, SL, BH, BN, BL, SR, SN, SW, BR, BN, BW, SC, SN, SA, BC, BN, BA, SG, SN, SD, BG, BN, BD denote the market capitalization-weighted average portfolio return of each asset portfolio, respectively. Next, the factor construction methodology is as follows, utilizing the difference of portfolio returns of each period. Then, the difference of portfolio returns in each period is used to construct the FF5+ESG factor, and the factor construction method is as follows:

(i) MKT market premium factor

The data of market risk premium factor is obtained from the Cathay Pacific CSMAR database, considering that the listing time of the new KSCB stocks in 2019 is too short to consider the panel characteristics, then the market is determined by the composite A-share + GEM stocks, and the market risk premium factor is calculated by the formula:

MKT = Consolidated Monthly Market Return Considering Reinvestment of Cash Dividends (Market Capitalization Weighted Average Method) - Risk Free Rate

(ii) SMB factor

$SMB_{B/M}$ = (SH+SN+SL)/3 - (BH+BN+BL)/3

SMB_{OP} = (SR+SN+SW)/3 - (BR+BN+BW)/3

SMB_{Inv} = (SC+SN+SA)/3 - (BC+BN+BA)/3

SMB_{ESG} = (SD+SN+SG)/3 - (BD+BN+BG)/3

SMB=($SMB_{B/M}$ +SMB_{OP} +SMB_{Inv} +SMB_{ESG}) /4

(iii) HML factor

HML=(SH+BH)/2- (SL+BL)/2

(iv) RMW factor

RMW=(SR+BR)/2- (SW+BW)/2

(v) CMA Factor

CMA=(SC+BC)/2- (SA+BA)/2

(vi) ESG factors

ESG=(SD+BD)/2- (SG+BG)/2

Table 2 Factor construction table

Grouping methodology	locus (computing)	factorization algorithm
2×3 Size & B/M Size & OP Size & Inv Size & ESG	Size: 50% B/M: 30%, 70% OP: 30%, 70% Inv: 30%, 70% ESG: 30%, 70%	$SMB_{B/M}$ = (SH+SN+SL)/3 - (BH+BN+BL)/3 SMB_{OP} = (SR+SN+SW)/3 - (BR+BN+BW)/3 SMB_{Inv} = (SC+SN+SA)/3 - (BC+BN+BA)/3 SMB_{ESG} = (SD+SN+SG)/3 - (BD+BN+BG)/3 SMB=($SMB_{B/M}$ +SMB_{OP} +SMB_{Inv} +SMB_{ESG}) /4 HML=(SH+BH)/2- (SL+BL)/2 RMW=(SR+BR)/2- (SW+BW)/2 CMA=(SC+BC)/2- (SA+BA)/2 ESG=(SD+BD)/2- (SG+BG)/2

3. Pricing analysis of the six-factor model with the addition of ESG factors

3.1 Factor descriptive statistics

After constructing the factors described above, this chapter begins with descriptive statistics on the six factors to understand and compare the basic characteristics and distribution of the six factors over the sample period and provide a cognitive basis for subsequent regression analyses.

Table 3 Factor descriptive statistics

	count	mean	sd	min	p50	max
MKT	132	0.589	6.264	-25.063	0.653	17.780
SMB	132	0.898	4.523	-18.061	0.780	21.346
HML	132	0.005	3.372	-12.606	0.095	13.572
RMW	132	-0.091	2.605	-7.069	-0.202	7.209
CMA	132	0.078	2.170	-5.501	0.072	5.578
ESG	132	-0.102	1.828	-7.652	0.045	4.797

In terms of mean values, a positive MKT factor coefficient implies that the market risk premium is greater than zero. A positive SMB factor coefficient implies that small-capitalization stocks have a higher average excess return than large-capitalization ones, and a positive HML factor coefficient implies that highly valued stocks have a slightly higher average excess return than lowly valued stocks. A positive CMA factor coefficient implies that the market prefers to invest in aggressive firms. A negative RMW factor coefficient implies that firms with weak profitability instead have higher average excess returns. A negative ESG factor coefficient implies that firms with low ESG scores have higher average excess returns, and firms with high ESG scores are not statistically superior.

It is important to note that this statistic's results differ from the research hypothesis mentioned in the previous section and that the market does not recognize companies with high ESG scores. The possible reasons for this statistical result are that the calculation of the factor means creates a mean trap or is confounded by other relevant factors. Therefore, a more accurate way would be to test the risk premium after controlling for other risk factors.

3.2 Market Style Test

Compared with the descriptive analysis, academics are more concerned about whether the regression intercept terms of the remaining factors still have significant risk premiums after risk adjustment by the Fama-French three-factor model and regard this regression as a test of whether the dependent factors have style effects. Thus, we follow this method and regress the ESG factor returns calculated for the whole sample as the dependent variable and the three-factor model as the independent variable and the regression results are as follows:

Table 4 Market Style Test

	(1)	(2)	(3)
	RMW	CMA	ESG
MKT	-0.080***	0.001	0.037**
	(-2.623)	(0.049)	(2.126)
SMB	-0.410***	0.248***	0.268***
	(-9.279)	(6.159)	(9.247)
HML	-0.179***	0.532***	-0.080**
	(-3.283)	(12.005)	(-2.282)
_cons	0.326*	-0.149	-0.364***
	(1.932)	(-1.200)	(-3.671)
N	132	132	132
Adj. R^2	0.465	0.527	0.608

t statistics in parentheses

* p < 0.1,** p < 0.05,*** p < 0.01

From the results of the intercept term, the regression intercept term of the ESG factor, adjusted by the three-factor, is significantly different from zero and significant at the 99% confidence level. This suggests that there is a portion of ESG factor returns that cannot be explained by the traditional three-factor model , i.e., there is a significant ESG information effect in the adjusted risk premium of the stock portfolios within the sample.

3.3 Size-ESG 5x5 cross-grouped regression

To further test the role of the ESG factor, this paper uses the 2×3 method to calculate the factor, which averages the stocks in quintiles in the order of Size from small to large and ESG from low to high and then combines the two indicators of Size and ESG and cross-groups them. The calculated monthly excess returns of 25 portfolios were used as the explanatory variables, and the monthly factor return data of FF5 factor and FF5+ESG six-factor were used as the explanatory variables, grouped into regressions, and the regressions obtained were organized into Size-ESG tables. The asset pricing role of ESG factors is investigated by looking at the ESG factor coefficients obtained from the regression. (Due to space limitation, the regression results of other indicators of five and six factors are not listed, interested readers can contact us for a copy)

In addition, the CMA factor is a redundant factor in the “market style test”. Therefore, in the subsequent 5×5 subgroup regressions, we construct the orthogonalized CMAO investment style factor instead of the original CMA factor in strict accordance with the treatment of redundant factors in Fama and French (2015). As illustrated in that paper, the relevant conclusions drawn when evaluating the regression results against the regression results after substitution are consistent with those before orthogonalization.

Table 5 Size-ESG 5x5 cross-cohort regression results

				Book-to-market ratio						
ballpark	Low	2	3	4	High	Low	2	3	4	High
			Six-factor model (intercept)					t(a)		
Low	0.367**	0.419***	0.243**	0.429**	-0.013	2.520	3.031	2.051	2.602	-0.085
2	0.015	0.186	-0.020	0.069	-0.320***	0.112	1.224	-0.172	0.509	-2.727
3	-0.363***	-0.096	-0.151	-0.154	-0.207	-3.044	-0.937	-1.341	-1.105	-1.411
4	-0.195	-0.152	-0.070	-0.209	0.051	-1.550	-1.156	-0.568	-1.359	0.407
High	-0.057	-0.021	0.381**	0.062	0.154	-0.362	-0.118	2.445	0.409	1.525
			e (ESG factor)					t(c)		
Low	-0.042	0.016	-0.035	0.069	-0.386**	-0.311	0.105	-0.212	0.519	-2.529
2	0.477***	0.483***	0.144	0.138	-0.341***	3.616	3.546	0.979	0.913	-3.323
3	0.524***	0.556***	0.655***	0.175	0.224	3.853	3.844	4.376	1.371	1.443
4	0.756***	0.906***	0.634***	0.422**	0.481***	3.864	5.741	4.614	2.026	2.870

High	1.129***	0.702***	0.450***	0.083	-0.469***	7.107	4.149	2.674	0.490	-4.172
			Adj-R2					s(e)		
Low	0.971	0.967	0.977	0.967	0.967	1.603	1.751	1.442	1.717	1.797
2	0.978	0.971	0.975	0.968	0.968	1.381	1.558	1.427	1.575	1.610
3	0.972	0.973	0.966	0.968	0.960	1.449	1.427	1.537	1.569	1.630
4	0.954	0.961	0.965	0.951	0.949	1.753	1.645	1.530	1.783	1.735
High	0.943	0.935	0.916	0.930	0.963	1.669	1.769	1.974	1.770	1.166

3.3.1. Intercept term analysis

In the regression results for the 25 asset portfolios cross-classified by size and ESG score, the six-factor model has seven intercept terms significantly different from zero at the 1% and 5% significance levels. Four of these significant intercept terms are from the portfolios with the smallest market capitalization. It indicates that the ESG factors have a better explanation for all portfolios except small-cap stocks.

3.3.2. ESG factor coefficient analysis

Controlling for other factors, The ESG factor coefficients of 16 asset portfolios in the Size-ESG 5×5 subgroups pass the significance tests at the 1% and 5% levels, accounting for 64% of the total sample size, suggesting that the equity sample has some ESG information effects. Most ESG factor coefficients in the Size-ESG tables are positive, indicating that, in general, there is a positive correlation between the ESG score and the monthly excess returns are positively correlated, i.e., the higher the ESG score, the higher the monthly excess return.

With the same market capitalization grouping, the grouping results from smallest to largest ESG scores show that the portfolios located in the bottom 80% of ESG scores have positive ESG factor coefficients and higher future returns, indicating that for companies with low ESG scores, higher ESG scores lead to higher excess returns. For companies in the top 20% of ESG scores, on the other hand, the ESG factor coefficients are negative, and the higher the ESG scores, the lower the stock excess returns, suggesting that for portfolios with the highest ESG scores, the excess returns from ESG may be limited. It is worth noting that the ESG factor coefficients of small-capitalization companies are insignificant, suggesting that investors do not care about their ESG score status when investing in small-capitalization stocks.

Under the same ESG factor grouping, for groups (1) and (2) with the lowest ESG scores, the coefficients of the ESG factor are larger and significantly positive as the market capitalization increases, indicating that the larger the market capitalization, the higher the positive correlation between the ESG scores and the excess returns of the firms in the group with lower ESG scores. For the highest ESG group (5), the larger the market capitalization, the smaller and significantly negative the ESG factor coefficients, indicating that in the higher ESG score group, the larger the market capitalization, the higher the negative correlation between ESG score and excess return. This suggests that for large companies, raising the ESG score when it is low will bring positive feedback from the market. However, when the ESG score is already quite high, continuing to raise the score may trigger negative feedback from the market, and the higher the market capitalization of the company, the more significant this law is.

3.3.3. Adj-R2 Analysis

According to the Size-ESG 5×5 regression results, most of the Adj-R2 values of the 25 asset portfolios in the above table fluctuate between 0.95-0.97, with the highest degree of model fit. It indicates that the model has good explanatory strength in explaining the returns of the asset portfolios with Size-ESG scores, and almost no portion of the portfolio returns is not explained by the pricing factors.

3.4 GRS test

In contrast to the intercept term test in the previous subsection, which is primarily used to assess the fit of the model on 25 individual asset portfolios, the GRS test is a multiple hypothesis test for the entire model, which is used to holistically assess the pricing model's ability to explain the excess returns on all asset portfolios.

The GRS test is a statistical method proposed by Gibbons et al. in 1989 to test whether all model-adjusted intercept terms are simultaneously 0. This test is also used by Fama and French (2015 a; 2015 b) to test the validity of the five-factor model. Suppose the pricing model can fully explain the excess returns of all stock portfolios in the cross-section. In that case, the joint test of all portfolio regression intercept

terms should fail to reject the original hypothesis of simultaneous zero.

In addition to GRS, this paper uses another indicator, $A|\alpha_i|$, to measure the stability of the findings, whereis the absolute value of the regression intercept term for the ith stock portfolio, and $A|\alpha_i|$ is the average of the absolute values of 25 sets of regression intercept terms. The GRS and $A|\alpha_i|$ metrics measure, to varying degrees, the proportion of a stock portfolio's actual return that cannot be explained by the risk model, with smaller values indicating that the regression intercept term is closer to zero and the model is more explanatory.

Table 6 GRS test

25 Size-B/M combination	GRS	$A\|\alpha_i\|$
MKT SMB HML	2.573	0.293
MKT SMB HML RMW CMA	2.392	0.246
MKT SMB HML RMW CMA ESG	2.014	0.189
25 Size-OP combinations	GRS	$A\|\alpha_i\|$
MKT SMB HML	2.554	0.304
MKT SMB HML RMW CMA	2.317	0.238
MKT SMB HML RMW CMA ESG	1.905	0.185
25 Size-Inv portfolio	GRS	$A\|\alpha_i\|$
MKT SMB HML	2.465	0.298
MKT SMB HML RMW CMA	2.371	0.244
MKT SMB HML RMW CMA ESG	1.958	0.194
25 Size-ESG portfolio	GRS	$A\|\alpha_i\|$
MKT SMB HML	2.891	0.305
MKT SMB HML RMW CMA	2.855	0.259
MKT SMB HML RMW CMA ESG	2.414	0.197

Referring to Fama (2015), comparing the performance of the three-factor, five-factor, and six-factor models under different groupings in the above table, according to the above two measures of the performance of the regression intercept term, the test values of the two corresponding statistics of the three-factor, five-factor, and FF5+ESG six-factor models decrease in turn, with a gradual decrease in significance. Accordingly, we believe that the FF5+ESG factor model has the highest explanatory power in the A-share market, followed by the five-factor model, and the three-factor model is the worst, and this test result once again indicates that the addition of the ESG factor helps to enhance the explanatory power of the traditional factor model, and that there is a significant ESG information effect in China's stock market.

4. Research findings and policy recommendations

4.1 Conclusions of the study

In this paper, we take the companies with CSI ESG scores as the sample pool, establish the full sample stock portfolio, construct the FF5+ESG six-factor model to analyze the monthly data of A-share listed companies in 2012-2022, and draw the empirical conclusions as shown below:

First, in terms of the validity of the ESG factor, from the results of the market style test, the ESG factor is not redundant. Moreover, the results of Size-ESG 5×5 cross-group regression and GRS test also show that the inclusion of the ESG factor can enhance the model explanation strength, the ESG factor contains valid information that other factors do not have, and the ESG factor is a valid asset pricing factor.

Second, in terms of the selection of full-sample portfolio models, this paper finds that the FF5+ESG six-factor model with the addition of ESG factors has better explanatory power than the three-factor model and the five-factor model, and it makes the most sense to select it as the asset pricing model.

Third, in terms of the relationship between ESG performance and firms' excess returns, overall ESG performance is significantly positively correlated with excess returns. Specifically from the results of the Size-ESG 5×5 cross-sectional regression, the ESG factor coefficients are positive when the number of ESG scores is low, suggesting that boosting ESG scores when they are low leads to positive market feed-

back, but when they are already quite high (e.g., when the ESG scores are already in the top 20%), continuing to boost the scores can lead to limited market gains.

In summary, the empirical test results are interlocking and progressive, from descriptive statistics to empirical models and practical strategies, the empirical conclusions of different dimensions support that the ESG factor is an effective asset pricing factor, and the ESG performance positively and significantly affects the excess return. The empirical findings prove mechanistically that ESG inputs can bring excess returns, which strengthens the academic foundation for the theory and empirical evidence of ESG market scale expansion and supplements the gap of the ESG academic system in the field of asset pricing.

4.2 Policy recommendations

High ESG scores can bring excess returns. This research conclusion helps to break the hesitant attitude of enterprises to increase ESG investment, helps to dispel investors' doubts about whether ESG investment can bring excess returns, and can fundamentally promote the development of China's ESG system. Based on the research conclusion, this paper puts forward the following suggestions:

From the government's perspective, it should formulate and implement a series of laws and regulations covering environmental protection, social responsibility and corporate governance to guide and regulate the behaviour of enterprises and investors. From a corporate perspective, companies should integrate ESG factors into their long-term strategic planning to ensure their operations' environmental, social and governance sustainability. From an investor's perspective, investors should fully consider the ESG performance of companies in their investment decision-making process and prioritize companies that excel in environmental protection, social responsibility and good governance. Regulation, enterprises and investors should work together to promote the long-term sustainable development of the entire market.

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