Journal of Applied Finance & Banking, Vol. 12, No. 6, 2022, 57-76
ISSN: 1792-6580 (print version), 1792-6599(online)
https://doi.org/10.47260/jafb/1264
Scientific Press International Limited

China's Green Finance Premium Anomalies Based on Factor Models

Lianqian Yin[1] and Qiuju Wang[2*]

Abstract

The positive externalities of green producers usually reduce the company's earnings. Whether the markets give sufficient premium is important. Sampling the data of listed companies from May 2005 to April 2017 in Shanghai and Shenzhen A-share main-board markets, we construct 12 portfolios based on market factor RMRF, scale factor SMB, book-to-market factor HML and green factor GF. Results show: 1) SMB premium is significant positive, while HML is negative; 2) For green concept stocks, HML has a significant positive impact; 3) Portfolio with non-green concept stocks has a higher return; 4) GF has a significant negative risk premium on China's green concept stocks, and the premium level will decrease as the book-to-market ratio increases. The interpretation of the above premium anomalies improves national environmental protection policies which is of great significance for the formation of a sound environmental protection industry.

Keywords: Factor Model; Green Finance; Premium Anomalies; Excess Return; Environmental Protection.

[1] Associate Professor, International Business School, Jinan University.
[2] International Business School, Jinan University.*Corresponding author.

Article Info: *Received:* July 9, 2022. *Revised:* July 29, 2022.
Published online: August 4, 2022.

1. Introduction

China has achieved an economic leap forward since the Reform and Opening in 1978. However, the growth mode of the economy is based on the destruction of the environment and the predatory exploitation of resources. The long-term extensive economy and the lack of national consciousness of environmental protection have formed a high-growth, high-consumption and high-pollution economic growth mode, which has caused serious environmental problems. Frequent natural disasters, serious environmental pollution and increasingly scarce energy urge China to transit its economic growth mode from quantity-oriented to quality-oriented. According to the data from China Statistical Bureau, the traditional energy consumption, mainly including coal, oil and natural gas, accounts for 91% of China's total energy consumption in the past 30 years. According to the World Bank's report, the annual economic losses caused by environmental pollution have reached 3% of the total GDP during the same period. If we continue following the traditional economic growth mode, the number will exceed 13% in 2020. In the past 10 years, based on the mainstream mode of green finance in the first part of the environmental economic policy, the Ministry of Environmental Protection of China, together with China Banking Regulatory Commission, China Insurance Regulatory Commission and China Securities Regulatory Commission, successively issued Green Credit, Green Insurance and Green Securities, which set off a trend of Green Finance to protect the environment. Green securities are a vital part of the green financial system, and encouraging green investment is the key to promoting the transformation of China's economic development (Wei, 2008). In August 2016, the People's Bank of China and the Ministry of Finance jointly issued the Guiding Opinions on Building a Green Financial System. The document aims to promote the development of the green industry through the establishment of national green development funds, re-loans, interest subsidies, and guarantees, which could further improve the green financial system. Therefore, some scholars pay attention to the relationship between green finance and economic development. Haiyang Qiu (2017) finds that green finance in both broad and narrow senses has a significant role in promoting economic growth. Mohammad (2017) indicates that eco-friendly producers contribute to the shared value (economic and social value) of stakeholders. Other scholars study the impact of listed companies' environmental performance on market performance and financial performance. Shen and Ma (2014) find that good environmental performance of enterprises helps to obtain more and longer-term new loans. Xinyi Li et al. (2015)uses the case of Zijin Mining to explain that the environmental performance problems of enterprises will bring regulatory risks and operational risks. Since creditors do care about the environmental performance of enterprises, it will also affect debt financing ability. Na Sha (2012) indicates that it is difficult for enterprises implementing environmental strategies to make up for short-term costs, so environmental strategies lack economic advantages. Mathur and Mathur (2000) find that companies with green market business often have significant negative stock price responses due to the cost of greening. Clemens(2006)

shows that there is a positive correlation between environmental performance and financial performance, and when small enterprises have green economic incentives, the positive correlation between environmental performance and financial performance is greater. While Horvathova (2010) finds a negative correlation between environmental performance and financial performance. Clarkson et al. (2011) find that the positive correlation between environmental performance and financial performance is strong, based on the data from four main polluting industries in the United States. But such a green strategy does not apply to all enterprises. Wahba (2008) believes that good environmental performance can effectively increase the value of listed companies. Some scholars also pay attention to the income and risk characteristics of green portfolios. Chen (2014) points out that the risk of green stocks is not entirely related to the general stock risk. They also show that constructing a portfolio with a certain proportion of green concept stocks can bring diversification and hedging effect to investors. Chia et al. (2009) show that green concept stocks have their own risk and yield characteristics. The company's scale, industrial characteristics and geographical location cannot explain the stock premium of renewable energy companies. If all the factors affecting stock investment are analyzed, the green factor, which stands for the company's environmental performance, is significant in the stock market. Criscuolo and Menon (2015) verify that the green industry has unique risk characteristics.

Markowitz's (1952) portfolio theory points out that the stock risk consists of systematic risk and non-systematic risk. Fama and French (1992) point out that the book value and the market value can jointly reflect the characteristics of company size, company value, earnings per share and leverage through empirical research. Based on CAPM, Fama and French (1993) introduce the risk premium(SMB) of the portfolio with small-scale stocks relative to the portfolio with big-scale stocks and the risk premium (HML)of the portfolio with value stocks relative to the portfolio with growth stocks, which explains the expected return of a cross-sectional portfolio. The model is widely approved by academia and practitioners soon after it is put forward. However, many researchers find that some phenomena cannot be explained by the three-factor model in the stock market. Some researchers analyze those phenomena from the perspective of behavioral finance. Carhart (1997) extracts the momentum factor from the momentum effect and introduce it into the three-factor model to construct a four-factor model. Baker and Wurgler (2006) introduce investor sentiment index into Carhart's four-factor model, and construct a five-factor model to study the impact of the volatility of investor sentiment on stock returns. Some scholars try to explain those phenomena by improving the three-factor model. Aharoni et al. (2013)indicate that there is a significant negative correlation between the company's capital investment and expected return.

Novy-Marx (2013) finds that the profitability of listed companies has the same explanatory power to book-to-market ratio when predicting stock returns, and the expected profitability is positively correlated with the stock portfolio yield. In order to better describe the expected return rate of the stock portfolio on the cross-section, Fama and French (2015) introduce a profitability factor and an investment style

factor based on the three-factor model to construct a five-factor model. After two years, they (Fama & French, 2017) find that with the increase in book-to-market ratio and profitability, the average stock return in North America, Europe, and Asian-Pacific region increased simultaneously. But the investment style factor negatively correlates with the average stock return. And for Japan, the average stock return rate is significantly related to the book-to-market ratio, but it has little to do with profitability factor or investment style factor.

The empirical research on the three-factor model in the domestic academia has different conclusions because of different research methods, such as sample size, sample interval, factor construction, grouping criteria and so on. Wang and Zhu (2011) point out that the three-factor model has low pricing interpretation ability in China's stock market. The market scale has no significant explanatory power, while the bond market indicators such as repo rate, term spread, investment proportion and ratio of stock price to cash flow have significant interpretation ability on stock market risk premium. Lihui Tian et al. (2014) prove that the risk of China's stock market is particularly prominent through empirical research. The stock return rate is more sensitive to market risk than the US, and the premium for the book-to-market ratio is not significant. Zhibing Li et al. (2017) point out that under the full sample, the scale factor and the book-to-market factor rare significant. After being adjusted by the three-factor model, the profitability factor and the investment style factor are still significant, but there is no significant momentum or reversal effect. In addition, the five-factor model is more explanatory than the CAPM, three-factor model and Carhart's four-factor model.

The empirical analysis of our research is based on the construction method of Fama-French's three-factor model. Then we introduce the green factor to construct a four-factor model. Considering China's accounting standards, we made some adjustments to the time selection and interval grouping of the data. In order to keep the integrity of the data, we choose the representative data of Shanghai and Shenzhen A-share main-board market from May 2005 to April 2017 for analysis. We also exclude the samples that affect the validity of the data and retain the relevant monthly data for regression analysis. The significance of our research is that, firstly, we can explore the relationship between green development concept and excess return by studying the performance of green concept stock in the stock market. Secondly, by constructing a green factor, the applicability of the factor model to excess return rate of green concept stock is explored and the three-factor model is further improved. Thirdly, by analyzing the specific implementation effect of China's green industrial policy, reference for the supply-side green reform and investors' decisions would be provided.

We divide the paper is into four parts. The first part is the introduction. We elaborate the relevant academic research on risk premium of green concept stock. Then we summarize the development of the factor model used in our research and the achievements of factor model that domestic and foreign scholars made. The second part is the model description and sample selection. We explain the four-factor model, the source of samples, the criteria of data selection and the construction of pricing

factors. The third part is the empirical analysis. We put forward descriptive statistical analysis of the data, and then carry out a regression diagnosis of the data and a significance analysis of the factors based on the established four-factor model. The last part is the conclusion. We summarize the empirical results of our research and put forward reasonable advice on the development of the green industry.

2. Model and sample

2.1 Theoretical model

American scholars Sharp (1964) propose the Capital Asset Pricing Model (CAPM)on the basis of asset portfolio theory, which studies the quantitative relationship between the return and risk of risky assets in the stock market. The model is as follows:

$$\overline{r_a} = r_f + \beta_a(\overline{r_m} - \overline{r_f}) \tag{1}$$

Where $\overline{r_a}$ is the expected return of a single stock or a stock portfolio; r_f is the risk-free return rate; β_a is the beta coefficient, indicating the systemic risk of the stock or the portfolio; $\overline{r_m}$ is the expected market return; $(\overline{r_m} - \overline{r_f})$ is the equity market premium, which is the difference between the expected market return and the risk-free return rate.

The model divides the price of all risky assets into three factors: the risk-free return rate, the price of risk and the risk unit. And it combines these three factors to enable investors to evaluate and select financial assets based on absolute risk rather than total risk. However, the Capital Asset Pricing Model has certain limitations, which are manifested in the following reasons: First, the assumption is difficult to achieve. Second, the beta coefficient of the model is difficult to estimate.

Fama and French (1992)propose the famous Fama-French three-factor model to explain the excess return of assets by carefully studying the characteristics of stocks that obtained excess returns in the US capital market. They pointed out that the excess return rate of an asset can be explained by three factors: the market factor (RMRF), the scale factor (SMB) and the book-to-market factor (HML). The specific model is as follows:

$$R_{it} - R_{ft} = a_i + \beta_i(R_{mt} - R_{ft}) + s_i SMB_t + h_i HML_t + \varepsilon_{it} \tag{2}$$

Where R_{it} is the yield of portfolio i (or stock i) during the period t; R_{ft} means the risk-free return rate during the period t and then $(R_{it} - R_{ft})$ represents the excess return of the portfolio i (or stock i) during the period t; R_{mt} means the return rate of the market portfolio during the period t, and then $(R_{mt} - R_{ft})$ represents the excess

return of the market portfolio during the period t. SMB_t (small minus big) represents the scale factor, which is the difference of return between the portfolio with small-scale stocks and the portfolio with big-scale stocks in the period t. HML_t (high minus low) represents the book-to-market factor, which is the difference of return between the portfolio with high book-to-market ratio stocks and the portfolio with low book-to-market ratio stocks in the period t. β_i is a factor proposed in CAPM model to measure the exposure degree of systemic risk of investment targets, standing for the sensitivity of market factor. s_i stands for the sensitivity of the portfolio i (or stock i) to the scale factor. h_i stands for the sensitivity of the portfolio i (or stock i)to the book-to-market factor. a_i is the intercept term and ε_{it} is the residual term. The Fama-French three-factor model has been verified and approved by academia, and it has been widely used in practice.

Carhart (1997) introduces the momentum pricing factor based on the three-factor model and constructs a four-factor model. The model makes up for the deficiency of the three-factor model in explaining the trend effect of cross-sectional return anomalies, but it is still insufficient in explaining the excess return in the stock market. Fama and French (2017) consider that the three-factor model cannot completely explain the expected return rate, so they introduce RMW, a profitability factor to explain the profitability effect, and CMA, an investment style factor to explain the investment style effect, to construct a five-factor model. Then they clearly point out that even the five-factor model is not complete, and there are other factors that are not explained, so the model needs to be further improved. It also indicates that it is necessary to improve the factor model and conduct in-depth research on different types of innovation.

Through the study of the stock market, we find that the green concept stock has a unique performance in the market compared to the non-green concept stock. On the one hand, the green industry is of great significance to the sustainable development of the economy. Therefore, the government will introduce a series of policies to support the development of green industry, and these policies will also bring considerable potential benefits to the companies. Although such kind of operating income is difficult to realize in the company's book income, it will improve investors' expectations of the company's future development. On the other hand, green concept companies have special systemic risks, and investors will demand higher risk compensation accordingly. Specifically, energy conservation and environmental protection technologies have higher research and development costs, a longer payback period and a lower technology conversion rate, which makes green concept companies difficult to quickly take the current market share.

However, traditional technologies still have a dominant position. It can be seen that the green concept has become an important factor affecting the excess return rate of stock.

The four-factor model after introducing the green factor is as follows:

$$R_{pt} - R_{ft} = a_p + \beta_p (R_{mt} - R_{ft}) + s_p SMB_t + h_p HML_t + g_p GF_t + \varepsilon_{pt} \quad (3)$$

Where GF_t is the green factor, it is the difference of return between the portfolio with green concept stocks and the portfolio with non-green concept stocks, eliminated the impact of the scale factor and the book-to-market factor. g_p is the sensitivity of the target portfolio p to the green factor. If g_p is positive, it indicates that there is an excess return on green concept stocks compared with non-green concept stocks. Although the market reaction to green projects is uncertain now, holding green concept stocks will get higher return, so investors will be willing to purchase it. If g_p is negative, it indicates that there is no obvious excess return for green concept stocks compared with non-green concept stocks.

2.2 Sample source and selection

We select the sample from May 1st in 2005to April 30th in 2017. In the sample interval, China's stock market witnessed bear and bull, consolidation and rally, formation and collapse of the blue chip bubble and the small and medium board stock bubble. Therefore, the data of the stock market from 2005 to 2017 is very representative and full of research value. Furthermore, the data start on May 1st in 2005because China's law stipulates that the listed company should released its annual report publicly within 4 months after the end of each fiscal year. So, at the end of April, we can get accurate data from the company. If public information has an impact on stock return, it will react after May. Therefore, the data start from May in t year and end in April in t+1 year, which constructs an annual period. At present, China's stock market still lacks a systematic and authoritative green evaluation system. Therefore, we divide the stocks into the green concept stocks and non-green concept stocks according to the energy conservation and environmental protection board in the CSMAR Database. The board only includes listed companies whose main business or technology is related to energy conservation and environmental protection. These companies have applied energy conservation and environmental protection technology in their production and operational activities, which are more environmentally friendly. Although such a distinction is rough and simple, it can basically distinguish whether it is a green concept stock or not. We choose the stocks in energy conservation and environmental protection board as the representative of the green concept stocks. And we set the rest in Shanghai and Shenzhen A-share main board market as a comparison. The data come from the CSMAR Database. We exclude ST stocks and PT stocks. In China, ST and ST* stocks indicate that listed companies are confronting operational difficulties or in poor financial conditions. The book-to-market ratio of such stocks are often abnormal, which will cause certain difficulties in sorting. In addition, the returns of ST stocks often

fluctuate greatly. The reasons for fluctuation are largely due to insider trading, and there are different price limits compared with normal stocks. The daily fluctuation rate is limited to 5%, and its trading mechanism and risk are different from ordinary stocks. For PT stocks, its liquidity is quite different from normal stocks. We also exclude financial stocks. Financial stocks account for a large proportion of the market value, so the evaluation of market value will be biased. For example, when grouping, most financial stocks will be divided into portfolio with big-scale and high book-to-market ratio stocks, so that financial stocks will have a greater impact on the return of the portfolio. We exclude stocks of companies with a negative owner's equity, for its book-to-market ratio is meaningless. We exclude stocks with missing data. Stocks lacking monthly yield, total market value and book value will be excluded. Therefore, according to the Fama-French three-factor model and its modified model, the listed companies and market data required for our research include risk-free return rate, total market value, owner's equity, stock monthly yield, market yield, and so on. Considering the situation of China's capital market, we choose the one-month bond yield to maturity as the risk-free return rate, and the raw data is Chinese government bond yield to maturity. The company's financial data including the total market value, owner's equity and so on, come from the annual report. The calculation of the monthly return rate does not consider the reinvestment of cash dividends. Some scholars use the return of the stock index as the market return rate. The sample selected in our research include most of the A-share main-board stocks in Shanghai and Shenzhen. It will be biased to singly choose Shanghai or Shenzhen stock index return as the market return. Hence, we choose the monthly return of Shanghai and Shenzhen 300 Index as the market return rate.

2.3 Construction of pricing factors

Based on the ratio of owner's equity to total market value at the end of December in the t-1 year and the total market value at the end of April in t year, we divide the green concept stocks from May in the t year to April in the t+1 year. For each period of data, the stocks are sorted in descending order by the market value scale and divided into two groups according to the median. The top 50% listed companies in the ranking are divided into Group B (portfolio with big-scale stocks), and the bottom 50% listed companies are divided into Group S (portfolio with small-scale stocks). Then, according to the book-to-market ratio of selected sample companies, the listed companies in each scale are ranked in descending order respectively. The top 30% listed companies in the book-to-market ratio ranking are divided into Group H (portfolio with high book-to-market ratio stocks), the middle 40% are divided into Group M (portfolio with medium book-to-market ratio stocks), and the bottom 30% are divided into Group L (portfolio with low book-to-market ratio stocks). In this way, six groups of stock portfolios will be obtained, namely Group B/H, Group B/M, Group B/L, Group S/H, Group S/M and Group S/L. For non-green concept stocks, we will divide them according to the grouping standard of green concept stocks. Specifically, we first exclude the non-green concept stocks

whose market value scale or book-to-market ratio is out of the ceiling and floor of the green concept stocks. Then, based on the grouping point on the market value scale and the book-to-market ratio used in green concept stocks, the non-green concept stocks are grouped. In this way, the non-green concept stocks are also divided into six groups, namely Group B/Hc, Group B/Mc, Group B/Lc, Group S/Hc, Group S/Mc, and Group S/Lc. Finally, the weighted average of the relative market value of each stock (the ratio of the market value of each stock to the sum market value of stocks in the group) is used to get the average monthly return rate of each portfolio. Then we calculate the monthly values of SMB and HML based on it.

Now we construct a green factor based on existing data. Based on the above work, we get six groups of monthly average portfolio returns with green concept stocks and non-green concept stocks respectively (twelve groups in total). In the corresponding group, we subtract the return of portfolio with non-green concept stocks from the return of portfolio with green concept stocks, and then we obtain six groups of yield. The value of the green factor is the average of the six groups of monthly returns. The formula is as follows:

$$GF = \frac{1}{6}\sum_{i=1}^{6}(R_i - R_{i,c}) \tag{4}$$

Where R_i represents the monthly return of each green portfolio. $R_{i,c}$ represents the monthly return of each non-green portfolio. However, considering the phenomenon of the simultaneous rise and fall in China's stock board market, the green factor based on formula may lead to a mechanical correlation between the green concept company's return and the green factor. To avoid this problem, we build a new green factor based on sample from all companies in the A-share market. Specifically, we first exclude the non-green concept stocks whose market value scale or book-to-market ratio is out of the ceiling and floor of the green concept stocks. Secondly, we divide all the companies in the sample into six groups based on the market value scale and the book-to-market ratio using the same method. Then each group is divided into Group G (portfolio with green concept stocks) and Group NG (portfolio with non-green concept stocks). Finally, 12 groups of stock portfolios are constructed, namely Group B/H/G, Group B/H/NG, Group B/M/G, Group B/M/NG, Group B/L/G, Group B/L/NG, Group S/H/G, Group S/H/NG, Group S/M/G, Group S/M/NG, Group S/L/G and Group S/L/NG. If there is no significant difference in the yield of the two types of stocks in the stock market, then the green factor we constructed will not affect the stock return rate. That is, the coefficient of the green factor is not significant. On the contrary, if the coefficient of the green factor is significant, it indicates that the environmental protection factor will have an impact on the stock return rate. So, there will be a yield difference between the green concept stocks and the non-green concept stocks. If the coefficient is significantly positive, it shows that the return rate of green concept stocks will be higher than that

of non-green concept stocks. If the coefficient is significantly negative, it shows that the return rate of green concept stocks will be lower than that of non-green concept stocks.

3. Empirical analysis

3.1 Data description

Table 1 shows the descriptive statistics of each factor we constructed. From the table, we can find that the average premium of RMRF is -2.2256 per month; the average premium of SMB is 0.0127 per month; the average premium of HML is -0.0002 per month; the average premium of GF is -0.0013 per month. Since the mean of SMB is significantly larger than zero, we can conclude that the portfolio with small-scale stocks has a higher yield. Similarly, the mean of HML is significantly less than zero, which indicates that the portfolio with low book-to-market ratio stocks has a higher yield than the portfolio with high book-to-market ratio stocks. This is different from the conclusion of Fama and French's research on the American stock market. Their research believes that companies with high book-to-market ratio will have a higher average return than the market, which indicates that the situation of Chinese and American stock market is different. The mean of HML is higher than the average risk premium of RMRF, which indicates that the undervalued stocks in the market have investment value. The mean of GF is also less than zero, which indicates that the portfolio with non-green concept stocks has a higher return than the portfolio with green concept stocks, which is different from our assumption that green concept stocks have a higher return. From the perspective of standard deviation, RMRF fluctuates most, while SMB, HML and GF fluctuate less.

Table 1: Descriptive statistics of each factor

	Minimum	Maximum	Mean	Standard Deviation
RF	0.7268	4.9752	2.2493	0.8334
RM	-0.2585	0.2793	0.0135	0.0934
RMRF	-5.0199	-0.0047	-2.2256	0.8688
SMB	-0.1824	0.1683	0.0127	0.0451
HML	-0.1045	0.1609	-0.0002	0.0382
GF	-0.0998	0.0673	-0.0013	0.0225

Note: RF is the risk-free return rate. RM is the market return. RMRF (the market return minus the risk-free return rate) is the market factor. SMB is the scale factor. HML is the book-to-market factor.GF is the green factor.

Table 2: Mean and standard deviation of monthly average return of each portfolio

Scale		Book-to-market ratio					
		H		M		L	
		NG	G	NG	G	NG	G
Mean	B	3.03%	2.48%	2.92%	3.07%	2.91%	3.00%
	S	4.05%	4.43%	4.36%	4.02%	4.34%	3.82%
Standard deviation	B	10.98%	11.11%	10.55%	10.29%	10.15%	11.18%
	S	11.43%	13.09%	11.79%	12.19%	12.14%	12.13%

Note: B/S stands for the portfolio with big-scale stocks and small-scale stocks respectively. H/M/L stands for the portfolio with high book-to-market ratio stocks, medium book-to-market ratio stocks and low book-to-market ratio stocks, respectively. NG/G stands for the portfolio with non-green concept stocks and green concept stocks respectively.

Table 2 describes the mean and standard deviation of the monthly average return of 12 portfolios in the sample interval. In Group B/H, Group S/M and Group S/L, the portfolio with non-green concept stocks have a higher monthly average return than the portfolio with green concept stocks. While in Group S/H, Group B/M and Group B/L, the portfolio with green concept stocks has a higher monthly average return than the portfolio with non-green concept stocks. From the perspective of the market value scale, the monthly average return of the portfolio with small-scale stocks is higher than that of the portfolio with big-scale stocks. We have the same results as most scholars who study the Fama-French three-factor model. It is consistent with the results that the mean of the scale factor is greater than zero. It shows that small-scale stocks have higher return in China's stock market. The standard deviation of the portfolio return can partly reflect the systematic risk. The standard deviation of the monthly average return of 12 portfolios ranges from 10.15% to 13.09%, so the systematic risk is high. In Group S, the standard deviation of the monthly average return of portfolios with non-green concept stocks decrease with the increase of book-to-market ratio. On the contrary, the standard deviation of the monthly average return of portfolios with green concept stocks increases with the increase of book-to-market ratio. In Group B, the standard deviation of the monthly average return of portfolios with non-green concept stocks increase with the increase of book-to-market ratio. However, the difference between the standard deviation of the monthly average return of portfolios with green concept stocks is smaller. Specifically, the standard deviation of the portfolio with low book-to-market ratio stocks is the largest, followed by the portfolio with high book-to-market ratio stocks and the portfolio with medium book-to-market ratio stocks. Portfolios with small-scale stocks have a larger standard deviation of monthly average return than portfolios with large-scale stocks.

3.2 Data diagnosis

Table 3: Pearson correlation coefficient of six green portfolio excess returns with four factors

Green Portfolio	RMRF	SMB	HML	GF
BHG	0.9984	0.2730	0.9012	-0.9018
	(0.0000)	(0.0009)	(0.0000)	(0.0000)
BMG	0.9982	0.2664	0.9034	-0.9029
	(0.0000)	(0.0012)	(0.0000)	(0.0000)
BLG	0.9971	0.2681	0.9007	-0.8993
	(0.0000)	(0.0012)	(0.0000)	(0.0000)
SHG	0.9948	0.2717	0.9002	-0.8980
	(0.0000)	(0.0010)	(0.0000)	(0.0000)
SMG	0.9956	0.2771	0.9015	-0.8989
	(0.0000)	(0.0008)	(0.0000)	(0.0000)
SLG	0.9946	0.2677	0.9019	-0.8979
	(0.0000)	(0.0012)	(0.0000)	(0.0000)

Note: The p-value of t statistic is in parentheses. RMRF represents the market factor, SMB represents the scale factor, HML represents the book-to-market factor, and GF represents the green factor. Vertical axis consists of six green portfolios classified by market value scale and book-to-market ratio.

Table 3 shows the Pearson correlation coefficient of six green portfolio excess returns with four factors. The data above each cell is the correlation coefficient between the excess return and the factor, and the p-value of the corresponding t statistic is in parentheses below. RMRF and HML both have a strong positive correlation with the excess return of each green portfolio, and they are significant at the probability level of 1%. SMB has a small positive correlation with the excess return of each green portfolio, and it is significant at the probability level of 1%. GF has a large negative correlation with the excess return of each green portfolio, and it is significant at the probability level of 1%.

Table 4: Pearson correlation coefficient and variance inflation factor of four factors

	RMRF	SMB	HML	GF
RMRF	1.0000			
	-			
SMB	0.2688	1.0000		
	(0.0011)	-		
HML	0.2046	0.2265	1.0000	
	(0.0000)	(0.0063)	-	
GF	0.2059	0.2282	0.2982	1.0000
	(0.0000)	(0.0059)	(0.0000)	-
VIF	2.7110	1.0063	1.3861	1.4182

Note: The p-value of t statistic is in parentheses. RMRF is the market factor, SMB is the scale factor, HML is the book-to-market factor, and GF is the green factor.

Table 5: Unit root test results of variables

Variable	ADF	P value	ADF Critical Value $(\alpha = 0.01)$	Conclusion
BHG	-9.7151	0.0000	-3.4768	Stationary
BMG	-9.4321	0.0000	-3.4768	Stationary
BLG	-9.9367	0.0000	-3.4768	Stationary
SHG	-9.6405	0.0000	-3.4768	Stationary
SMG	-9.8650	0.0000	-3.4768	Stationary
SLG	-9.4515	0.0000	-3.4768	Stationary
RMRF	-9.4781	0.0000	-3.4768	Stationary
SMB	-8.8576	0.0000	-3.4768	Stationary
HML	-9.0781	0.0000	-3.4768	Stationary
GF	-9.0876	0.0000	-3.4768	Stationary

Note: BHG-SLG represents six green portfolios classified by market value scale and book-to-market ratio. RMRF is the market factor, SMB is the scale factor, HML is the book-to-market factor, and GF is the green factor.

Table 4 is the Pearson correlation coefficient between RMRF, SMB, HML and GF. The variance inflation factor is at the bottom of the table. The data above each cell is the correlation coefficient between each factor, and the p-value of the corresponding t statistic is in parentheses below. We can find that the correlation coefficients between the four factors do not exceed 0.3, and the data indicate that there is no linear substitution relationship among the factors. Moreover, the variance inflation factor is much less than 10, indicating that there is no multicollinearity between RMRF, SMB, HML and GF.

We also carry out the unit root test on RMRF, HML, SMB, GF and the excess returns in first difference. The test results are shown in Table 5. The unit root test results show that the absolute value of the ADF statistic of RMRF, SMB, HML, GF and excess returns in first difference are both greater than 8, which is far greater than the critical value of 1%, 5% and 10%. Therefore, we can reject the unit root hypothesis. The time series of RMRF, SMB, HML, GF and excess returns in first difference are both stationary.

3.3 Results

Table 6: Regression results of six green portfolios

Green portfolios	BHG	BMG	BLG	SHG	SMG	SLG
	(1)	(2)	(3)	(4)	(5)	(6)
_cons	0.0004	-0.0007	-0.0017	-0.0002	0.0004	-0.0001
RMRF	1.0767***	1.0151***	1.1005***	1.0864***	1.1203***	0.9978***
SMB	-0.0875	0.0500	0.0024	-0.1503	-0.1744**	0.0063
HML	0.1124	0.2725***	0.5612***	0.6836***	0.856***	1.1052***
GF	-0.0821	-0.3502***	-0.6561***	-0.6163***	-0.7754***	-1.1124***
R^2	0.9746	0.9753	0.9713	0.9429	0.9598	0.9728
N	138	122	135	135	122	131

Note:***, **, and * denote the levels of statistical significance at 1, 5 and 10 percent, respectively.

We first analyze the results of the overall regression test of the model. As is shown in Table 6, the adjusted R-squared of six regressions is all above 94%, indicating high explanatory power of the model. The lowest adjusted R-squared is 94.29%, which appears in portfolio SHG. The model is successful.

Then we analyze the regression results of each factor. The test results of the intercept term show that it is not significant at the probability level of 5%, so we accept the null hypothesis. It means that the model can explain the excess return of

green portfolios well. The results are similar to the research of Deng (2006) and Zeng (2014) that the intercept term of the factor model is usually zero. Market factor has a positive impact on the excess return of green portfolios. The regression coefficient of RMRF is significant at the probability level of 1%, which indicates that market factor is a very important factor, and the result is consistent with the conclusions of most scholars. Moreover, except for portfolio SLG, the regression coefficient of RMRF of other green portfolios is slightly larger than 1, indicating that the risk of portfolios is slightly greater than market. The regression coefficient of SMB is not significant at the probability level of 1%, so we accept the null hypothesis. It shows that the scale factor is not significant in China's energy conservation and environmental protection board market. HML has a good explanation for the green portfolios except for portfolio BHG.

The regression coefficient of GF is significant and negative except for portfolio BHG, indicating that green factor has a negative effect on the excess return of green investment. On the one hand, this phenomenon may be due to the fact that the national policy to support the green industry is still insufficient. On the other hand, compared with traditional industries, the emerging green industry has a larger investment cost in technology and a longer payback period. The positive social and environmental externalities produced by the green industry cannot be transformed into the company’s earnings. And there are high costs caused by pollution elimination, energy conservation, and emission reduction. Moreover, energy conservation and environmental protection companies in China set up late, and most of them are still in the stage of investment outweighing income. There is another anomaly that the green factor has a greater negative impact on green portfolios with small-scale stocks than green portfolios with big-scale stocks. And with the increase of book-to-market ratio, its negative impact on the excess return of green portfolios will reduce. Compared with small-scale companies, big-scale companies will usually receive more support from the national policy, and they are easy to grasp the opportunities for industrial development. They can also expand through strategic reorganization, enabling them easier to reorganize resources and optimize allocation. Therefore, the green factor has a less negative impact on their excess return.

3.4 Robustness analysis

Table 7: Test results of robustness analysis based on subsample regression

Green portfolios	BHG	BMG	BLG	SHG	SMG	SLG
	2005-2010					
	(7)	(8)	(9)	(10)	(11)	(12)
_cons	0.0002	-0.0004	-0.0027	0.0012	0.0021	-0.0008
RMRF	1.1428***	1.0670***	1.1964***	1.1505***	1.1260***	1.0825***
SMB	0.0001	0.1137	0.0443	-0.1260	-0.1677**	0.0538
HML	0.1404*	0.3467***	0.5953***	0.6917***	0.8910***	1.1444***
GF	-0.0186	-0.3216**	-0.5734***	-0.5451***	-0.7100***	-1.1115***
$\overline{R}^2$	0.9658	0.9782	0.9689	0.9721	0.9312	0.9668
N	62	59	61	60	55	55
	2010-2017					
	(13)	(14)	(15)	(16)	(17)	(18)
_cons	-0.0003	0.0017	0.0023	-0.0013	-0.0016	0.0028
RMRF	1.1544***	1.0841***	1.1830***	1.1414***	1.2067***	1.0193***
SMB	-0.0674	0.1261	0.0392	-0.0958	-0.1509**	0.0955
HML	0.1657	0.2739***	0.6540***	0.7732***	0.9164***	1.1869***
GF	-0.0597	-0.2526**	-0.6231***	-0.5164***	-0.7146***	-1.0922***
$\overline{R}^2$	0.9659	0.9685	0.9526	0.9466	0.9445	0.9623
N	76	63	74	75	67	76

Note:***, **, and * denote the levels of statistical significance at 1, 5 and 10 percent, respectively.

In 2010, China established the Energy Commission and adopted the Mid-term Evaluation Report of the National Environmental Protection Eleventh Five-Year Plan, which strengthened the responsibilities of the government and companies. The government ought to strictly implement the target responsibility system in environmental protection and unremittingly reduce emission and pollution to ensure the realization of the environmental protection policy during the Eleventh Five-Year Plan period. Hence, taking 2010 as the break point, we divide the original sample into two subsamples, 2005-2010 and 2010-2017. Then we test the coefficients of the constructed model again. Table 7 is the test results of a robustness analysis based on subsample regression. Except for regression (7), regression (11) and regression (14), the test results of the two subsamples are consistent with the original results, which indicates that the conclusions in our research are robust.

4. Conclusions and advice

Based on domestic and foreign research of the factor model, we introduce a green factor to the Fama-French three-factor model to study the premium anomalies of China's green concept stocks. The sample period is from May 2005 to April 2017. We choose the energy conservation and environmental protection board stocks in the CSMAR Database as representatives of green concept stocks. Then we analyze the significance of the market factor, scale factor, book-to-market factor, green factor and their effects on the excess return of green concept stocks. The main conclusions are:

(1) SMB has a significant positive risk premium, while HML has a significant negative risk premium. Specifically, small-scale companies have higher return than big-scale companies, and low book-to-market companies can achieve higher return than high book-to-market companies. The mean and standard deviation of the monthly average return of the portfolio with small-scale stocks are higher than the portfolio with big-scale stocks. And the mean of SMB is greater than zero, while the mean of HML is smaller than zero.

(2) For green concept companies, HML has a significant positive impact. And in the green portfolios with small-scale stocks, the standard deviation of monthly average return increases with the increase of book-to-market ratio. In the green portfolios with big-scale stocks, the difference between the standard deviation of monthly average return is smaller. The standard deviation of the green portfolio with low book-to-market ratio stocks is the largest, followed by the green portfolio with high book-to-market ratio stocks and the green portfolio with medium book-to-market ratio stocks.

(3) Compared with green portfolios, non-green portfolios have a higher return rate. To a certain extent, it reflects the investors' low attention and recognition to the green concept stocks. The factors that positively affect the excess return rate are derived from others, such as RMRF and HML. The mean of GF is significantly less than zero.

(4) GF has a significant negative risk premium on China's green concept stocks, and the premium level will decrease as the book-to-market ratio increases. In addition to SMB, all factors have high explanatory power for the premium anomalies of China's green concept stocks. Among them, RMRF and HML have a positive impact on the excess return of green concept stocks. While GF has a negative impact on the excess return of green concept stocks, and its negative impact decreases with the increase of book-to-market ratio. The reasons behind it may be the impact of the implementation of national policies. But whether the green factor is a long-term effective risk pricing factor deserves further study.

According to China's current situation, we propose to establish a more detailed and standardized green concept evaluation system. The four-factor model with a green factor effectively explains the premium anomalies of green concept stocks. Refining and standardizing green concept evaluation system is conducive to a more in-depth study of whether the concept and practice of green development have an impact on

China's stock market, and how the influence mechanism works. So it can better provide advice to investors and reference for the government to implement relevant policies. Therefore, it is necessary to speed up the construction of a more authoritative and detailed green concept evaluation system, especially in the green technology assessment and environmental risk assessment.

We also need to strengthen the support and construction of the environmental protection industry. Compared with traditional industries, the emerging green industry has larger investment costs at the early stage, a longer payback period and a lower technology conversion rate. Even the positive social and ecological externalities produced by the green industry cannot be transformed into the company's income. There are also high costs caused by pollution elimination, energy conservation and emission reduction. Moreover, energy conservation and environmental protection companies in our country set up late and have great resistance for development. Most energy conservation and environmental protection companies are still at the stage of investment outweighing income. The government and the financial system are urged to introduce relevant policies to promote the basic constructions for the development of green finance. The government should also actively guide the development of green finance and green industry. By constructing a better ecological business circle of the green industry, the investors and the society will more identify with the green investment culture.

ACKNOWLEDGEMENTS

We thank for the supports from National Social Science Foundation [grant number 21BGL264].

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