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THE PERFORMANCE
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COVID-19:
A COMPARATIVE
STUDY WITH BLACK
FUNDS AND
CONVENTIONAL
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The Performance of China Green Funds around the COVID-19: A Comparative Study with Black Funds and Conventional Funds

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Abstracts: The analysis covers 102 green funds, 64 black funds, and 434 conventional funds in China, comparing their performance over 93 sample intervals from November 2015 to July 2023. The performance of green and black funds is significantly higher than that of conventional funds over the entire sample period, primarily due to the greater impact of COVID-19 on the industries in which conventional funds invest. Notably, green funds outperform black funds. When dividing the sample period at the onset of COVID-19, it is found that conventional funds generally outperform green and black funds before the pandemic, while green and black funds significantly outperform conventional funds during COVID-19. After COVID-19, as the state promotes economic recovery, conventional funds again outperform green and black funds. Overall, the performance of green funds gradually improves over time, with increased investment in large-cap and growth stocks.

Keywords: Green funds; Black funds; Conventional funds; COVID-19.

Introduction

From October 26 to 29, 2015, the Fifth Plenary Session of the 18th Central Committee of the Communist Party of China (CPC) put forward for the first time the concept of green development, which of course cannot be supported without a green finance. The recent outbreak of the COVID-19 crisis has posed a significant threat to the development of green finance. Assessing the performance of green markets in the three periods before, during and after COVID-19 is necessary as it can reflect the willingness of investors to continue investing based on the performance of green markets in response to a major crisis event, as well as the dramatic fluctuations and changes in the

performance of green markets after such an exceptional event.

Socially Responsible Investing (SRI) requires investments based on socio-ethical criteria such as the sustainability of expected stable profits, compliance with laws, employment practices, respect for human rights, level of social contribution, and concern for the environment, in addition to conventional financial indicators (Sally Hamilton, 1993). Socially responsible investment fund has not yet become the mainstream investment choice. That is mainly due to the fact that when people choose a specific investment direction, it represents investing in a limited number of securities, and they cannot reasonably invest their funds in the most effective market portfolio, thus having to bear a certain ESG risk exposure (Markowitz, 1952).

Green funds, as a subset of socially responsible investment, are required to incorporate environmental, social, and responsible corporate governance concepts in sustainable investments. They must encourage investments that generate positive environmental and social externalities, and select companies that are environmentally friendly, increase energy efficiency, protect the natural environment, perform research and development in cleaner technologies and use alternative cleaner sources of energy for their investments. At the same time, this single investment direction is exposed to the risk of green sustainability (Ibikunle and Steffen, 2015).

The direction of investment of black funds is to some extent the opposite of green funds, which mainly invest in companies involved in the consumption of natural non-renewable energy and carbon emission-intensive companies. As China's policy and financial support for green development is in its infancy, the ferrous industry's unregulated exploitation and the near-negligible cost of externalities have kept the ferrous industry at the top of the list of benefits, allowing funds investing in the ferrous industry to make significant returns. However, after 2015, China made a series of policy and financial measures to control carbon emissions, resulting in an increase in the efficiency of green innovation in China (Bai et al., 2023).

In emerging countries, to ensure a secure energy supply and the stable growth of national economies, the fossil fuel and natural resources industries are steadily expanding. Today, fossil energy is gradually being replaced by clean energy, and the green sector is gradually replacing the former role of the black sector. To ensure the stable development of clean energy and renewable energy in times of crisis, China not only supports the development of the green industry, but also ensures that the black industry can benefit from a stable energy supply, so as to guarantee that the

country can get through the crisis unscathed, and that there is no great difference in the impact of COVID-19 on the two industries.

In the context of China's strong support for the development of green industries and the increase in the production costs of black industries, we present our first proposition on the comparison of the performance of green funds and black funds. We believe that the Green Fund will either outperform the Black Fund or perform no differently than the Black Fund, and there will be no difference in performance between the Green Fund and the Black Fund at the time of COVID-19. As the green industry is encouraged and supported by the State, the risks faced by the investment of green funds will be reduced, while the black industry is inhibited and regulated by the Government, so the risk factors faced by the investment of black funds will be increased.

In this paper, conventional funds are defined by excluding funds investing in green and black industries, and the remaining funds are collectively referred to as conventional funds, whose investment sectors mainly include accommodation and catering, management services, retailing, culture and education, construction, real estate and agriculture, forestry, animal husbandry and fishery. Investments in conventional industries are primarily concerned with costs and benefits, and companies typically outperform when technological and business opportunities coexist. Both of these opportunities are influenced by trends in the economy; If the economy is doing well, then conventional companies will perform well, and if the economy continues to deteriorate, then conventional companies will perform poorly. The COVID-19 incident has caused a severe economic decline in China and globally, with those companies and industries that rely on China as their primary manufacturing base and source of raw materials suffering severe supply-side impacts. For instance, industries such as automobile manufacturing, electronics manufacturing, textiles and apparel. According to the United Nations Conference on Trade and Development, in the first quarter of 2020, global trade fell by more than 3%, with trade in Asia falling by more than 25%. Accordingly, we make a second proposition regarding the comparison of the performance of green funds and conventional funds. We believe that until COVID-19 occurs, conventional funds have outperformed green funds due to their stability and continuity of returns, as well as the fact that China's economy reached a certain climax in 2018 and 2019. While at the time of COVID-19, conventional sectors are disproportionately hit by COVID-19, so conventional funds have underperformed or be indistinguishable from green funds. Finally, after COVID-19, there has been a little difference in

the economic performance of the two fund types, and the performance of green funds relative to conventional funds will get better over time.

We examined 600 open-end equity funds listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange, which contain 102 green funds, 64 black funds, and 434 conventional funds datasets. The financial performance of the three fund types from November 2015 to July 2023 is compared based on the methodology of the (Fama and French, 2015) five-factor model which could better explain the Chinese stock market. Our findings show that green funds and black funds outperform conventional funds throughout the sample interval, with green funds outperforming black funds. After segmenting the sample interval, conventional funds perform best before COVID-19 occurs, and there is no significant difference between the performance of green and black funds. The conventional fund performed the worst during the occurrence of COVID-19, and there was no difference in performance between the green and black funds. After the end of COVID-19, the Black Fund was the worst performer, and there was no difference in the performance of the Green Fund and the conventional funds. We also find asymmetry in the exposure of the three types of fund investment companies, with green funds having a large exposure to growth stocks and a shift from small-cap to large-cap exposure, black funds having a large exposure to aggressive companies, and conventional funds having a larger exposure to profitable companies.

Literature review

(Sally Hamilton, 1993) provided the first comparative study of social responsibility fund performance, by proposing three possible performance hypotheses for SRI funds. A subset of scholars has argued that investors in SRI funds invest on the basis of certain specific beliefs and therefore bear the financial costs of investing in such beliefs (Allevi et al., 2019; Renneboog et al., 2008). The SRI Fund also bears the cost of the risk of not being able to diversify its investments, since it has a very limited choice of investment pools and does not have a wide range of investment sources. These have contributed to the risk-adjusted underperformance of SRI funds compared to diversified fund categories (Martí-Ballester, 2019). Another subset of scholars argues that SRI funds have led to greater specialization in investment direction, such specialization allows fund managers to focus on long-term investments and hence better identify companies with high risk-adjusted

returns. This specialized and stable pool of capital also allows these companies to engage in more efficient technological innovation and development, and benefit from their financial performance, so SRI funds have higher risk-adjusted returns than other traditional fund categories (Ito et al., 2013). (Bauer et al., 2002) address the issue of benchmarking funds by using (Carhart, 1997) multifactor model to study 103 ethical funds in an international database for the period 1990-2001. They reveal that ethical funds begin to turn gradually better after a period of strong underperformance, and UK ethical funds significantly outperform conventional funds in the latter part of the sample period. (Cortez et al., 2009), by examining socially responsible funds in Europe, found that there was no significant difference between the performance of socially responsible funds and conventional funds in general, furthermore, socially responsible funds invested more in conventional funds than in socially responsible indices.

(Muñoz et al., 2014) analyzed green funds and other socially responsible funds in the United States and Europe found that green responsible funds in the United States performed much better during the financial crisis and the opposite in the European market. (Mallett and Michelson, 2010) based on parametric and non-parametric tests found no significant investment difference in performance of green funds, socially responsible funds compared to index funds. (Ito et al., 2013) used dynamic-mean-variance to study SRI funds and environmentally friendly funds in the U.S. and the EU, and the results showed that environmentally friendly funds did not perform as well as SRI funds.

As China promotes a green financial system, incentives for investors to invest in green funds may switch from belief-driven to economically-driven (Aguirre and Ibikunle, 2014). Alternatives to fossil energy and their sustainable environmental orientation can be an advantage in reducing the cost of carbon, so investing in green portfolios is increasingly supported by economic and financial arguments. Green funds are increasingly competitive with fossil energy funds (Aguirre and Ibikunle, 2014; Lanoie, 2008). (Ibikunle and Steffen, 2015) used the Carhart four-factor model to comparatively analyze the financial performance of green funds, black funds, and conventional funds in Europe over the period 1991-2014. They found that these green funds significantly underperformed conventional funds and were not significantly different when compared to black funds, but over time the performance gap between green funds and conventional funds became smaller, evolving from underperforming black funds to no significant difference in performance

between them. (Climent and Soriano, 2011) compared the performance of U.S. green and conventional funds from 1987-2009 by pairing them. The study showed that green funds underperformed traditional funds over the sample period, but there was no difference between the performance of green funds and that of conventional funds at the end of the sample period, from 2001 to 2009. These findings are consistent with (Martí-Ballester, 2019) study of EU sample results. (Ito et al., 2013), on the other hand, found that SRI funds in the EU and the US outperformed the performance of conventional funds, with environmentally friendly funds performing as well as or better than conventional funds.

The outbreak of COVID-19 in 2019 could make a difference in the performance of green funds, black funds and conventional funds. (Agoraki et al., 2023) analyzes that the financial support of the three largest green investment funds in Europe at the time of COVID-19 had a positive impact on green assets, and that positive impact was more pronounced when the fund returns were negative. (Silva and Cortez, 2016) also confirmed, by examining green funds in the U.S. and in Europe, that during the crisis events during crisis events, green funds perform better compared to the market. (Muñoz et al., 2014) analysis found that green funds did not perform worse than other socially responsible funds or conventional funds. Subsequently, in terms of the ability of these funds to manage during the financial crisis, US green fund managers realized superior performance during the crisis, while the opposite occurred for managers in the European market. (Zhang et al., 2023) examined fund ESG performance from 2018-2021 and found that fund ESG performance is positively correlated with fund downside risk over the sample period. However, this positive correlation weakened during the COVID-19 epidemic. (Xu, 2021) examines the impact of COVID-19 on China's real economy showing that industries heavily invested in by traditional funds, such as restaurants, services, tourism, and transportation, are the most significantly impacted.

The related literature on the comparison of the performance of green, black and conventional funds has mainly examined developed economies such as Europe and the U.S. Little attention has been paid to the study of green funds targeting green investment themes in large green emerging markets such as China, where the rapid development of mainland China's securities is providing financial products that can lead to greater diversification and diversification of global fund investments (Martí-Ballester, 2021). After the outbreak of COVID-19 in 2019, few studies have also investigated the comparative performance of green, black, and conventional funds in China.

Therefore, we provide a comparison of the performance of the three types of funds before, during, and after COVID-19, and examines the different performances of the three types of funds' investment behaviors and investment returns during the crisis period, which could be a tangible contribution to the assessment of China's policies towards the development of green finance and the green investment preferences of the investors.

Data and Methodology

Data

We selected November 2015 as the starting point of the sample period to study the comparative performance of green funds, and July 2023 as the sample period end point. The entire sample period contains 93 months or approximately 8 years of monthly fund data. In particular, the COVID-19 period began with the naming of the virus by the World Health Organization, and ended with the declaration by the National Health Commission of the People's Republic of China that COVID-19 was not under control. All funds selected in our study are open-end equity funds listed on the Shanghai Stock Exchange and Shenzhen Stock Exchange, with more than 80% of their investment assets in stocks. In order to eliminate errors between the three types of funds caused by age of establishment, size, etc. We select black and conventional funds by conditionally matching them with green funds. The matching conditions are the age of the fund, the size of the fund at the end of the sample period and the size of the investment objective. In calculating the return on net assets of the Fund, we use the risk-adjusted total return on net assets in order to take into account the reinvestment of dividends and capital distributions. To prevent endogeneity issues arising from fund survivor bias, we consider funds that closed during the sample period to be included in the fund sample, with data up to the month of closure. In order to prevent the effects of fund return extremes, we have winsorized the three selected categories of funds by 1% and 99% of the fund's annualized collection rate, respectively. Finally, funds with less than 12 months of data are excluded. The division of funds comes from the Choice Financial Terminal and the Wind database of fund categories and industry classifications, and the raw data are all from the CSMAR database.

Table 1 Funds sample distribution

MF class	Number of MFs	type of MF	Sample periods	average age	average size
Green	102	Open equity	93(month)	61(month)	\$47.5M
Black	64	Open equity	93(month)	75(month)	\$29.5M
Conventional	434	Open equity	93(month)	70(month)	\$24.8M

The table provides basic information on funds selected in accordance with the fund categorization criteria and data processing standards in this paper. The average size of the funds is denominated in U.S. dollars for the sample period: 2015.11-2023.07.

Funds Data

In our study we consider that the investment direction of green funds focuses on at least one aspect of ESG and at least 50% of their equity assets is related to sustainable development, environmental friendliness, and renewable energy. And they select the industries involved in comprehensive utilization of waste resources, ecological preservation and environmental governance, water management and renewable energy industries such as solar energy, wind power, tidal energy, geothermal energy, bio-energy and hydroelectricity. According to the above fund data processing, 102 green funds were finally selected, of which 72 were established for issue and trading after November 2015.

The selection process of black funds is basically the same as the selection of green funds. Black funds invest at least 50% of their equity assets in non-renewable energy sources, consume natural resources and have high carbon emissions, and select the coal mining and washing industry, oil and gas extracting and refining industry, ferrous metal mining and processing industry, non-ferrous metal mining and processing industry, other mining industry, non-metallic mineral products industry, ferrous metal smelting and calendaring processing Industry, Non-Ferrous Metals Smelting and Metal Manufacturing Industry. According to the above processing of fund data, the final selection, there are 64 black funds, of which 46 were established for issue and trading after November 2015.

Conventional funds are selected by excluding the green funds and black funds that we selected from all open-end equity funds extracted from CSMAR database. In addition to excluding funds

that focus on investing in the financial sector, and those regulated by a specific sector. Again, according to the processing of the above fund data, 434 traditional funds were finally selected, of which 309 were established after November 2015 to issue and trade.

Table 1 summarizes the basics of the three types of funds that make up the dataset.

Factor Portfolios

We use the five-factor model proposed by Fama and French (Fama and French, 2015), and the data columns contain five proxy variables: 1. Market factor: excess market returns; 2. Size factor: the difference in the returns of small-cap portfolios versus large-cap portfolios for the past 12 months; 3. Value factor: the difference in the returns of high book-to-market portfolios versus low book-to-market ratio portfolios for the past 12 months; 4. Profitability factor: the difference in returns of high-profitability portfolio versus a low-profit portfolio over the past 12 months; 5. Investment factor: the difference between a low investment ratio portfolio and a high investment ratio portfolio over the past 12 months. The risk-free rate is the benchmark 3-month time deposit rate issued by the China central bank. The above factors are based on data obtained from the entire financial market in China, and the data on the five proxy variables and the risk-free rate during the sample period are obtained from the CSMAR database.

Methodology

In order to examine the performance of sustainability-oriented investment returns compared to the performance of the other two types of investment returns, the risk characteristics of green funds were examined and compared to black funds and conventional funds, which have broadly similar characteristics. The data for the three types of funds are obtained from regression analysis based on an econometric unbalanced panel. Risk-adjusted return is one of the criteria for evaluating investment performance, our study is based on the CAPM model and uses the measure of (Jensen, 1968) α indicator, which can be used to measure the excess performance of a fund's investment after considering the market heterogeneity. if $\alpha > 0$, it means that the fund has achieved excess return and its performance is better than the general market performance; if $\alpha = 0$, it means that the fund has not achieved excess return and its performance is the same as that of the general market

performance; and if $\alpha < 0$, it means that the fund's excess return is negative and its performance is poorer than that of the general market performance.

The CAPM one-factor model takes the following form:

$$r_{i,t} - r_{f,t} = \alpha + \beta_{i,MKT}(r_t^m - r_{f,t}) + \varepsilon_{i,t} \quad (1)$$

In particular, the market factor is obtained by subtracting the market risk-free return from the market portfolio, and the market portfolio return uses the market benchmark data provided by the CSMAR database. However, considering that the conditions under which the CAPM is established are too strict to explain the stock investment return situation well, the study of (Huang, 2019) investigated the degree of explanation of the factor model on the Chinese stock market and showed that the five-factor mode can better explain the stock excess return. We further adopt the five-factor model, which is an extension of the original CAPM model and the extension of Fama&French's three-factor model. The five-factor model includes, in addition to the single market factor (MKT), the size factor (SMB), the value factor (HML), the profitability factor (RMW), and the investment factor (CMA), and is modeled in the following form:

$$r_{i,t} - r_{f,t} = \alpha + \beta_{i,MKT}(r_t^m - r_{f,t}) + \beta_{i,SMB}r_t^{smb} + \beta_{i,HML}r_t^{hml} + \beta_{i,RMW}r_t^{rmw} + \beta_{i,CMA}r_t^{cma} + \varepsilon_{i,t} \quad (2)$$

where $r_{i,t}$ is the return of the fund portfolio in month t ; $r_{f,t}$ is the market risk-free rate of return in month t ; r_t^m reflects the return of the market portfolio in month t ; $\beta_{i,MKT}$ measures the market risk exposure coefficient of the fund portfolio; if $\beta_{i,MKT} > 0$, then it indicates that the fund portfolio's operating trend is in line with that of the market as a whole. consistent with the overall market trend, if $\beta_{i,MKT} > 1$, then the fund will react faster than the market and behave more aggressively; $\beta_{i,SMB}$ measures the small company effect of the fund's investment portfolio, if $\beta_{i,SMB} > 0$, then the fund's investment portfolio prefers investing in the stocks of small-capitalization companies; $\beta_{i,HML}$ measures the value premium effect of the fund's portfolio, and if $\beta_{i,HML} < 0$, it indicates that the fund's portfolio prefers investing in growth-oriented company stocks; $\beta_{i,RMW}$ measures the highly profitable company effect of the fund's portfolio, and if $\beta_{i,RMW} > 0$, it indicates that the fund's portfolio prefers investing in profitable company stocks; and $\beta_{i,CMA}$ measures the conservative company effect of the fund's portfolio, and if $\beta_{i,CMA} > 0$, it indicates that the fund's portfolio prefers investing in conservative company stocks.

In order to be able to compare the performance of green funds, black funds, and conventional

funds, we learn from (Ibikunle and Steffen, 2015) and achieve the performance comparison by adding dummy variables for fund categories to the Fama & French five-factor model, with up to two dummy variables at a time added to Equation (2) in order to prevent the effects of multicollinearity: Green Fund Dummy Variable and Black Fund Dummy Variable, or Green Fund Dummy Variable and Conventional Fund Dummy Variable. The positive or negative coefficients of each dummy variable can demonstrate the performance among the three types of funds. The specific form of their equations is as follows:

$$\gamma_{i,t} - \gamma_{f,t} = \alpha + \beta_{i,MKT}(\gamma_t^m - \gamma_{f,t}) + \beta_{i,SMB}\gamma_t^{smb} + \beta_{i,HML}\gamma_t^{hml} + \beta_{i,RMW}\gamma_t^{rmw} + \beta_{i,CMA}\gamma_t^{cma} + \gamma_{i,G}D_{i,G} + \gamma_{i,B}D_{i,B} + \varepsilon_{i,t} \quad (3)$$

$$\gamma_{i,t} - \gamma_{f,t} = \alpha + \beta_{i,MKT}(\gamma_t^m - \gamma_{f,t}) + \beta_{i,SMB}\gamma_t^{smb} + \beta_{i,HML}\gamma_t^{hml} + \beta_{i,RMW}\gamma_t^{rmw} + \beta_{i,CMA}\gamma_t^{cma} + \gamma_{i,G}D_{i,G} + \gamma_{i,C}D_{i,C} + \varepsilon_{i,t} \quad (4)$$

Equation (3) will realize the comparison of traditional fund performance with green fund performance and black fund performance, where $D_{i,G}$ is a green fund dummy variable, which takes the value of 1 if fund i belongs to the green fund, otherwise it is 0. $\gamma_{i,G}$ indicates the impact of funds belonging to the green category on fund i . If the coefficient $\gamma_{i,G}$ is significantly greater than 0, it indicates that the green fund performance is better than the conventional fund performance; if the coefficient $\gamma_{i,G}$ is not significant, it indicates that there is no difference between the performance of green funds and the performance of conventional funds; if $\gamma_{i,G}$ is significantly less than 0, it indicates that the performance of green funds is worse than the performance of conventional funds.

$D_{i,B}$ is a black dummy variable, which takes the value of 1 if fund i belongs to the black fund, and 0 otherwise. $\gamma_{i,B}$ indicates the impact of funds belonging to the black category on fund i . If the coefficient $\gamma_{i,B}$ is significantly greater than 0, it means that the performance of black funds performs better than the performance of conventional funds; if the coefficient $\gamma_{i,B}$ is not significant, it means that the performance of black funds does not differ from conventional fund performance; if $\gamma_{i,B}$ is significantly less than 0, it indicates that black fund performance is worse than conventional fund performance.

Similarly, equation (4) enables the comparison of black fund performance with green fund performance and conventional fund performance in a discriminatory manner consistent with the above discussion. Combining equations (3) and (4) accomplishes a two-by-two comparison of

performance among the three types of funds.

In order to prevent the existence of between-group heteroskedasticity or between-group contemporaneous correlation of the disturbance term $\varepsilon_{i,t}$ from affecting the validity of the regression estimation, we use the robust standard error of "between-group heteroskedasticity and between-group contemporaneous correlation", i.e., "Panel-Corrected Standard Error", which is referred to as PCSE, and still uses the panel OLS estimation procedure to determine the parameter estimation, except that it uses the standard error of PCSE.

Results and discussion

Table 2 Descriptive Statistics of Funds

MF Class	Green	Black	Conventional
Mean Return (%)			
2015.11-2023.07	0.542	0.504	0.188
Standard Deviation (%)			
2015.11-2023.07	6.412	6.8623	7.152
Mean Return (%)			
2015.11-2019.12	0.461	0.362	0.563
Standard Deviation (%)			
2015.11-2019.12	5.897	6.544	5.121
Mean Return (%)			
2020.01-2022.12	0.418	0.437	-0.159
Standard Deviation (%)			
2020.01-2022.12	7.069	7.381	7.871
Mean Return (%)			
2023.01-2023.07	0.698	0.518	0.968
Standard Deviation (%)			
2023.01-2023.07	5.298	5.765	4.529
N	102	64	434
ADF Test (Return)	I (0) stationary	I (0) stationary	I (0) stationary

Table 2 reports the statistical characteristics of the data for the three categories of funds. The last row reports the stability of the returns of the three types of funds.

We report descriptive statistics on the returns of the three fund types and the results are shown in table2. Based on our fund type screening criteria and data quality processing, 102 green funds, 64 black funds, and 434 conventional funds were selected. Throughout the sample period, the average monthly return of green funds (0.542%) is slightly higher than the average monthly return of black funds (0.504%) and higher than the average monthly return of conventional funds (0.188%) and is based on the standard deviation of the monthly returns. It shows that the conventional funds have the most volatile and the highest risky monthly returns (7.152%), while the green funds have the least volatile and the least risky ones (6.412%). The reason for this result is because most of the industries in which conventional funds are invested are more affected by COVID-19. This occupies almost half of the entire sample period, and therefore fund returns are more affected by COVID-19 as well. Table2 also shows a depiction of the average monthly returns of the three types of funds for three periods with the COVID-19 event as the time divider. Before COVID-19, when the economy continued to improve, conventional funds had the highest average monthly return (0.563%) and their risk was the lowest (5.121%), while green funds had a higher average monthly return and risk than black funds. The reason why conventional funds performed better than the other two types of funds prior to COVID-19 could be that the portfolio of invested assets was in line with optimal diversification and there were no restrictions on the direction of their investments. During COVID-19, the largest impact on conventional fund returns can be observed, with all three types of funds showing an increase in risk compared to the period before COVID-19, with the average monthly return of black funds (0.437%) slightly higher than the average monthly return of green funds (0.418%). After COVID-19, the economy rebounded and conventional funds largely returned to their pre-COVID-19 performance, with the highest average monthly return (0.968%) and the lowest risk. It is worth noting that the average monthly return of green funds (0.698%) is higher than the average monthly return of black funds (0.518%), and the volatility of green fund returns is lower than that of black funds. Moreover, the ADF test indicates that the monthly returns of the three types of funds are serially stationary over the entire sample period.

Table 3 FF Five factor regression results for the entire sample period (2015.11-2023.07)

Panel A	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	R_{ADJ}^2
Green	0.0024 ^{***}	0.9371 ^{***}	-0.1947 ^{***}	-0.5579 ^{***}	-0.0602	-0.2550	0.5671
Black	0.0017 ^{***}	0.9429 ^{***}	-0.0478	-0.5170 [*]	-0.2596 ^{**}	-0.4909 ^{***}	0.5611
Conventional	-0.0011 ^{***}	0.8792 ^{***}	-0.0590 ^{**}	-0.3488 ^{**}	0.1192 ^{***}	-0.1111 ^{**}	0.6534

Panel B	D_G	D_B	D_C
Conventional VS G&B	0.0029 ^{***}	0.0023 ^{***}	/
Black VS G&C	0.0007 ^{**}	/	-0.0023 ^{***}

The table reports the results of the random effects panel least squares regression based on the FF five factors. Panel A gives the estimation results of Eq (2) and Panel B gives the estimation results of Eq (3) and Eq (4). ^{***}, ^{**}and ^{*} indicating that they correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

In table3 we report the results of the FF five-factor regression for the entire sample period, where the market benchmark is obtained on the basis of the entire Chinese financial market. Over the entire sample period, both green and black funds significantly outperformed the market benchmark, earning risk-adjusted excess returns of 0.24% for green funds and 0.17% for black funds, and both were statistically significant at the 1% level. Conventional funds, on the other hand, significantly underperform the market benchmark, with an excess return of -0.11% that is lower than the excess returns of both green and black funds. Which causes the poor performance of conventional funds is the COVID-19, as it explained later in the regression results for the COVID-19 period. The performance of conventional funds is best explained by the FF five-factor model ($R_{ADJ}^2=0.6534$), which also indicates that conventional funds are indeed more diversified in their investments than green funds and black funds. Green funds and black funds, however, are affected by national policies and support in addition to market factors, so the explanatory power of the returns of the two types of funds is not as strong as the explanatory power of the model for conventional funds. In addition, green funds ($\beta_{SMB} = -0.1947$) have a significant preference for investing in large-

cap companies, contrary to our common belief that environmentally friendly and renewable energy companies do not have a large market capitalization, which may be due to the fact that many large companies in China, such as China National Petroleum Corporation (CNPC), China National Offshore Oil Corporation (CNOOC), and Golden Circle Corporation (JCEC) have undergone a green transformation, so it is not surprising to see that green funds are investing in these large-cap companies. Green funds ($\beta_{HML} = -0.5579$) have a significant preference for investing in growth companies, which is consistent with small but well-established new green businesses. Black Funds ($\beta_{CMA} = -0.4909$) is significant at 1% level, which indicates that Black Funds prefer to invest in aggressive companies throughout the sample period, which is more in line with the fact that unsustainable companies are risky and rewarding as their economic activities are highly influenced by natural factors and are exposed to uncontrollable risks. Conventional funds ($\beta_{RMW} = 0.1192$) are significant at the 1% level, indicating that conventional funds prefer to invest in profitable companies, which is consistent with the diversification objective of conventional funds. The regression results comparing the performance of the three types of funds are shown in Panel B. We can see that green funds outperform conventional funds' performance by 0.29% at a 1% significant level, and outperform black funds' performance by 0.07% at a 5% significant level. Black funds outperform conventional funds' performance by 0.23% at a 1% significant level. This indicating that in November 2015, since China vigorously develops green finance, green funds are not only supported by the state, but also favored by investors, and their overall performance is significantly higher than that of black funds and conventional funds.

We next divide the sample interval by using COVID-19 as a point in time and examine how the performance of the three types of funds changed before and after COVID-19.

Table 4 FF Five factor regression results before COVID-19 (2015.11-2017.07)

Panel A	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	R_{ADJ}^2
Green	0.0001	0.8572***	0.1000***	-0.0976***	-0.0998	-0.2367**	0.6309
Black	-0.001	0.8949***	0.1815***	0.1698	-0.2157	-0.5905***	0.7919

Conventional	0.0005	0.7875***	0.0625**	0.0282	0.2807**	-0.0998	0.6675
<hr/>							
Panel B		D_G		D_B		D_C	
<hr/>							
Conventional VS G&B		-0.0040***		-0.0031**		/	
Black VS G&C		-0.0009		/		0.0031**	
<hr/>							

The table reports the results of the random effects panel least squares regression based on the FF five factors. Panel A gives the estimation results of Eq (2) and Panel B gives the estimation results of Eq (3) and Eq (4). ***, **, and * indicating that they correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4 reports the results of the FF five-factor regression from 2015.11-2017.06, before the COVID-19 event. The risk-adjusted excess return α of all three types of funds is found to be insignificant, indicating that the performance of the three types of funds does not differ from the market performance. The high R^2_{ADJ} of the three types of funds ($R^2_{ADJ,G}=0.6309$, $R^2_{ADJ,B}=0.7919$, $R^2_{ADJ,C}=0.6675$) suggests that the five-factor model can explain the fund returns very well in this sample interval. The highest degree of explanation is found in black funds, which can be explained by China's building of a green financial system. In order to put a reasonable price on carbon emissions, China pushed for the construction of a carbon emissions trading market after November 2015, which puts an externality price on non-renewable firms engaging in carbon-emitting activities, making the cost of carbon for investing in such firms higher. So black funds have started investing in other sectors in order to reduce their carbon burden risk, making their portfolios more diversified, so the five factors can better explain the returns of black funds. Notably, green funds ($\beta_{SMB}=0.1000$) are significant at the 1% level, which differs from the results of the regression for the entire sample period. That's because in November 2015, China just proposed to build a green financial system, which encourages companies to transition to a green economy, but this transition process takes time to accumulate, big energy companies in this time has not yet found a good transition path, so the green fund invests in basically small-capitalization stocks that develop in line with the policy trend. During this period, conventional funds outperformed green funds by 0.4% and significant at the 1% level. Conventional funds outperformed black funds by 0.31%, which is significant at the 5% level. There is no statistically significant difference between the performance of green funds and black

funds. The regression results indicate that during the period from November 2015 to July 2017, when green finance was in its infancy, conventional funds demonstrated the advantages of Markowitz optimal portfolios.

Table 5 FF Five factor regression results before COVID-19 (2017.08-2019.12)

Panel A	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	R_{ADJ}^2
Green	0.0002***	0.8810***	-0.2187***	-0.5524***	-0.1920**	-0.0200	0.6758
Black	0.0010	0.9068***	0.1371*	-0.3698*	-0.1905	-0.8220***	0.6970
Conventional	0.0007**	0.8251***	0.2102***	-0.9178	0.3088***	-0.4128***	0.6663

Panel B	D_G	D_B	D_C
Conventional VS G&B	-0.0006*	-0.0010**	/
Black VS G&C	0.0004	/	0.0010**

The table reports the results of the random effects panel least squares regression based on the FF five factors. Panel A gives the estimation results of Eq (2) and Panel B gives the estimation results of Eq (3) and Eq (4). ***, ** and * indicating that they correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 shows the results of the FF five-factor regression for the second period before the COVID-19 event. August 2017 is chosen as the delineation point because this is the period in which China formally established the Green Fund and set up the National Green Development Fund in June 2018. The regression in this time interval can give us valuable comparative research on the development of Green Funds in the absence of any special risk events. During this period, both green funds and conventional funds earned risk-adjusted excess returns of 0.02% and 0.07%, which were significant at the 1% level and 5% level, respectively. The black funds, on the other hand, remained not significantly different from the market performance. The high R_{ADJ}^2 ($R_{ADJ,G}^2=0.6758$, $R_{ADJ,B}^2=0.6970$, $R_{ADJ,C}^2=0.6663$) for all three types of funds suggests that the five-factor model is still able to explain the fund's returns well in this sample interval, which continues to be attributed

to the good economic condition. The green fund ($\beta_{SMB}=-0.2187$) is significant at the 1% level, which is a departure from the previous period's investment preferences, and the shift of the green fund's investments to large-cap stocks could indicate that the energy majors have begun to undergo a green transition, and that certain criteria of economic activity have been met to meet the investment criteria of the green fund. The performance of green funds did not differ significantly from that of black funds during this period. Conventional funds continued to significantly outperform green and black funds by 0.06% and 0.1%, respectively. However, it is worth noting that the outperformance of conventional funds over green funds is only statistically significant at the 10% level in this period and has decreased from 0.4% over green fund performance in the previous period (2015.11-2017.07) to 0.06%. This suggesting that the performance of green funds has progressed in this period.

Table 6 FF Five factor regression results during COVID-19 (2020.01-2022.12)

Panel A	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	R_{ADJ}^2
Green	0.0036***	0.9889***	-0.2081***	-0.5578***	-0.1607	-0.1661	0.5236
Black	0.0041***	1.0083***	-0.0716	0.4574***	-0.4032**	-0.5937***	0.4829
Conventional	-0.0028***	0.9350***	-0.0419***	-0.2742***	0.0556	-0.3065***	0.3303

Panel B	D_G	D_B	D_C
Conventional VS G&B	0.0051***	0.0068***	/
Black VS G&C	-0.0017	/	-0.0068***

The table reports the results of the random effects panel least squares regression based on the FF five factors. Panel A gives the estimation results of Eq (2) and Panel B gives the estimation results of Eq (3) and Eq (4). ***, **and * indicating that they correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6 shows the results of the Fama & French five-way regression at the time of COVID-19. In January 2020, the World Health Organization (WHO) officially named the pneumonia COVID-19, which was chosen as the start of COVID-19. In December 2022 the National Health Commission

of the People's Republic of China declared that the COVID-19 virus is no longer lethal and officially liberalizes all international and domestic economic activities, which is chosen as the COVID-19 end point. The performance of the three types of funds changed dramatically over the period. Both green and black funds outperformed the market on a risk-adjusted basis ($\alpha_G=0.36\%$, $\alpha_B=0.41\%$), while conventional funds underperformed the market ($\alpha_C=-0.28\%$). Green funds outperformed conventional funds by 0.51%, and black funds outperformed conventional funds by 0.68%, and these statistical results are all statistically significant at the 1% level. This result is similar to (Nofsinger and Varma, 2014). The reason for the large drop in the performance of conventional funds during this period is that COVID-19 had a large impact on the industries in which conventional funds invested, and the decline in the level of industry performance led to a decline in the performance of conventional fund investments. The economic system losses caused by COVID-19 shocks varied widely across different industries, with construction, wholesale and retail trade, tourism services, accommodation and restaurants, and real estate being of concern. It is exactly because of the sensitivity of these sectors to crisis events that they performed so erratically when COVID-19 hit, resulting in conventional funds performing very differently from the results shown in tables 3, 4, and 5. The low $R_{ADJ,C}^2=0.3303$ also confirms that the portfolios of traditional funds are affected by unpredictable risk events. For the best performing black fund compared to the market performance, its ($\beta_{MKT,B}=1.0083$, $\beta_{HML,B}=0.4574$, $\beta_{CMA,B}=-0.5937$) market factor is significantly greater than 1, the value factor is significantly greater than 0, and the investment factor is significantly less than 0, all this suggesting a more aggressive investment trend in black funds compared to market portfolios, which is consistent with China's stabilization of the supply of oil, gas and electricity during the COVID-19 process. Because of policy support at the national level, these stocks bucked market economic performance during COVID-19, they continued to perform steadily when other sectors slowed down or even stagnated, and black fund investments were more aggressive than market investments during the difficult economic period, a claim supported by the lower $R_{ADJ,B}^2=0.4829$. It is for these reasons that the Black Fund's portfolio is more likely to stand out. Green funds also performed surprisingly well, improving rather than deteriorating facing the COVID-19 impact. It's excess return relative to the market increases from being significant at the 0.1 level to being significant at the 0.01 level, which demonstrates some continuity in the returns of green funds. As China's green financial system continues to improve, green investment opportunities

are increasing, government policies, standards, subsidies, and regulations are driving the steady development of the green economy, investors' understanding of the effects of green finance has deepened, leading to improved performance of green funds. It is a necessary part of the gradual transition of the economies of emerging countries from the era of fossil energy to the era of new energy and environmental protection.

Table 7 FF Five factor regression results after COVID-19 (2023.01-2023.07)

Panel A	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	R_{ADJ}^2
Green	-0.0027***	0.8958***	-0.2057***	-0.5554***	0.6247***	0.6075***	0.6373
Black	-0.0053**	0.8249***	-0.1855***	-0.7631***	0.8067***	-0.3112	0.5679
Conventional	0.0026	0.9032***	-0.3123***	-0.6717***	0.0843***	-0.1325	0.6229

Panel B	D_G	D_B	D_C
Conventional VS G&B	-0.0015	-0.0045***	/
Black VS G&C	0.0030*	/	0.0045***

The table reports the results of the random effects panel least squares regression based on the FF five factors. Panel A gives the estimation results of Eq (2) and Panel B gives the estimation results of Eq (3) and Eq (4). ***, **, and * indicating that they correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

After COVID-19, the economic recovery is poised to take off, with China adopting accommodative fiscal and monetary policies at the macro level, increasing liquidity in the market and encouraging investors to invest in weaker sectors. Encouraging people to consume at the micro level, with governments issuing consumption vouchers to revitalize the market for consumption. According to table 7, green funds and black funds significantly underperformed the market ($\alpha_G=-0.27\%$, $\alpha_B=-0.53\%$), while the performance of conventional funds did not differ from the market's performance, but over the same period of time, green funds significantly outperformed black funds by 0.3% at a level of 0.1, which is the first time that green funds outperformed black funds since the

beginning of the sample period. With the normalization of our economy after COVID-19, the rapid development of environmentally friendly enterprises, and the increasing attention paid by the government and investors to investments aimed at environmental protection, such investments will become more and more common. With the tightening of carbon emission restrictions and the increased demand for new energy sources making investors more aware of the risks of black funds, investments will gradually shift from the black industry to the green industry, and it is inevitable that green funds will outperform black funds. Moreover, there is no statistically significant difference between the performance of green funds and conventional funds, which also indicates the improving performance of green funds.

Table 8 Dynamic changes in comparison between Green funds, Conventional funds and Black funds

	2015.11-2017.07	2017.08-2019.12	2020.01-2022.12	2023.01-2023.07
	D_G	D_G	D_G	D_G
Conventional VS Green	-0.0040***	-0.0006*	0.0051***	-0.0015
Black VS Green	-0.0009	0.0004	-0.0017	0.0030*

The table reports the results of the random effects panel least squares regression based on the FF five factors. Estimates of Eq (3) and Eq (4) over four sample intervals are given. ***, **, and * indicating that they correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 8 provides a more visual representation of the change in performance of green funds versus conventional funds and black funds since November 2015. We can see that green funds performed significantly worse than conventional funds at the beginning of the sample period. With the improvement of China's green financial industry system, the continuous development of green financial instruments, and the maturity of fund managers and investors in green investment, the performance of green funds gradually becomes not significantly different from the performance of conventional funds. There was no difference in performance between green and black funds at the beginning of the sample period, with black funds gradually underperforming green funds as China's regime for the exploitation of fossil energy and natural resources became stricter, the carbon emissions trading system continued to improve, and black fund investors became more aware of risk.

Conclusion

In this paper we compared and analyzed the performance of green funds, black funds, and conventional funds in China by using COVID-19 as a point in time. (Renneboog et al., 2008) showed that socially responsible funds need to bear some social responsibility pricing in the Chinese market. As the green fund business has just started, the information asymmetry problem of green investment is more serious, which leads to the fact that investing in environmentally friendly funds may have to bear some green pricing, and the underestimation of the level of profitability that green funds may obtain may also cause the green funds to be mispricing. The most surprising finding of this research is that the green funds are the best performers in the entire sample interval, this funding is different from both previous (Climent and Soriano, 2011) and (Ibikunle and Steffen, 2015) studies. However, if we divide the sample interval into three time periods, before and after COVID-19, we can basically accept the conclusions of the previous studies that conventional funds outperformed green funds and black funds. But at the time of COVID-19, it is found that conventional funds underperformed far less than green and black funds because the investment portfolios of conventional funds are subject to the market impact is the most volatile. The unexpectedly better performance of green funds and black funds at the time of COVID-19 can be linked to China's energy security strategy, policies to promote the development of clean energy, stabilizing the level of innovation, increased transparency of information in the green market, and investors' growing awareness of environmental protection, which responded to more than just the performance of China's clean and energy markets, but also reflected China's policy direction. This helps the two types of funds' investment sectors to weather the impact of COVID-19.

In our focus on the energy transition, reflected in the performance of green and black funds in this paper, the comparison reveals that black funds are unable to significantly outperform green funds, which gradually outperform black funds over time. China has increased its support for corporate green innovation for the sake of sustainable development, and guided more market-based tools to help green incentives. The study found that green funds experienced a shift from a large exposure to growing small-capitalization firms to a large-capitalization firm over the sample period. It suggests that green incentives in China not only helped the development of new green firms, but also encouraged mature firms to make a green transition. The comparative results after COVID-19

show that green funds are gradually outperforming black funds, green development is becoming more market-oriented, green investments are more diversified, and the green investment burden borne by green investors is gradually eliminated. Whereas with the maturation of the carbon emission market, the regulation of non-renewable resources is increasing, the externality of black firms is being reasonably priced, and the risk borne by carbon-intensive risks borne by investors are also increasing. Consequently, the difference in performance between green and black funds will grow as fossil energy is coming to an end.

In general, the past performance of a fund is not a complete predictor of its future performance. With the rapid development of environmentally friendly enterprises in China and the increasing emphasis by the government and investors on investments for the purpose of environmental protection, more and more such investments will be made. That being so, the experience of fund managers and investors in investing in environmental protection funds will increase and, the investment performance of environmental protection funds is likely to get better and better in the future.

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