How Carbon Emission Affects Stock Returns and Business Management in China

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Abstract. This article explores whether carbon emissions affect the cross-section of Chinese stock returns. We find firms that could better manage their carbon emission have higher stock returns compared to their peers. On the contrast, carbon emission of firms do not have a significant relationship with stock returns. Moreover, Carbon emissions will affect the company's business strategy. In addition, the relationship between stock returns and firms' management ability of carbon emission is stronger among large firms. It indicates how firms manage their carbon emission might be more prominent for firm value and reputations among large firms, and it is already priced in the stock market.

Keywords: carbon emission · stock return · ESG · business management

1 Introduction

In the past 200 years, humans have emitted trillions of tons of carbon dioxide into the atmosphere. A large amount of carbon dioxide keeps the temperature rising. Carbon emissions have led to global warming and increased extreme weather events, posing a threat to life systems.

According to Our World data, the total carbon emissions of various industries in China in 2000 were 3.035 billion tons.1 The industry with the largest carbon emissions was the supply of electricity, gas and water. In 2010, all industries' total carbon emissions in China were 8.05 billion tons (compared to 2000 Annual growth of 165%). The industries that account for the largest proportion are still the supply of electricity, gas and water, non-metallic mineral products, and basic metal and metal products. In 2019, the total carbon emissions of various industries in China were 10.017 billion tons (compared to increased by 24.4% in 2010), accounting for 27.92% of the world's carbon emissions, creating a new high again.

Environmental problems such as environmental pollution, resource depletion, and ecological imbalance are becoming more and more serious, which are related to human survival and social development. It is necessary for countries to implement sustainable development strategies. The United Nations defines sustainable development as "While meeting the needs of contemporary people without compromising the ability of future generations to meet their own needs", it is an inevitable requirement to establish a

V. Gaikar et al. (Eds.): FMET 2022, AEBMR 227, pp. 793–802, 2023.
https://doi.org/10.2991/978-94-6463-054-1_86

modern economic system and an essential strategy for solving pollution problems. On this basis, countries around the world are beginning to make changes. First, a total of 195 countries signed the Paris COP21 climate agreement in December 2015, promising to limit global warming to 2 °C, which is far below the per-industrial level. At the same time, countries need to increase the financial industry's support for the carbon emission industry to reduce carbon emissions. China puts forward the development concept of "green finance". In August 2016, the twenty-seventh meeting of the Central Leading Group for Comprehensively Deepening Reform passed the "Guiding Opinions on Building a Green Financial System". The opinions pointed out that, to accelerate the development of green finance, we must use innovative financial system arrangements to guide and encourage more social capital flows to green industries; on the other hand, it is necessary to make full use of various financial tools such as green credit, green index, and green development funds to serve green development. In September 2017, General Secretary Xi Jinping also further reiterated the concept of "speeding up the reform of the ecological civilization system and building a beautiful China" in the report of the 19th National Congress of the Communist Party of China, and regarded "developing green finance" as one of the critical paths to promote sustainable economic and social development. Green finance and innovation, coordination, openness, and sharing have become China's "five core development concepts" in the new era, and this is also a consensus choice for global development. It is necessary to reform and improve related systems to promote economic development and ecological environment construction jointly.

Good corporate governance is vital for effective capital allocation, capital preservation and growth. This is an important condition for establishing a long-term sustainable enterprise. Unsustainable companies cannot provide appropriate long-term savings returns (that is, appropriate returns to shareholders), long-term employment in communities, or sustainable tax revenues for social (including environmental) development. From this perspective, poor governance is expensive for shareholders and other stakeholders.

This article systematically explores whether investors require a carbon risk premium by studying how stock returns vary with the carbon dioxide emissions of companies and industries. Through cross-sectional analysis and time series analysis, to explore whether carbon emissions affect China's stock returns.

We find that there is no significant correlation between carbon emission score and stock return, but there is a clear positive correlation between carbon emission management score and stock return. If the company can manage carbon emissions, it can promote the growth of the company's stock return. The carbon emission management score has a greater impact on companies with high market prices than on companies with low market prices.

2 Literature

2.1 The Relationship Between ESG and Stock Returns

The efficient market theory believes that the excess return rate of stocks is compensation for risk. Green incentives mean that green development risks receive specific risk compensation in the stock market. Therefore, the existence of green incentives is one of

the prerequisites for sustainable green finance. Through an empirical investigation of the impact of carbon emissions on German stock returns, Oestreicha and Tsiakasb (2015) find there is a huge and statistically significant carbon premium in stock returns, which can be as high as 17% per year. The carbon premium is caused by both the cash flow effect and the carbon risk effect.[2] As a result, businesses, especially those in carbon-intensive industries, face increased risks in the form of increased costs. As carbon-emitting companies face carbon risks, they need higher expected returns than companies with lower carbon emissions. Vespermann and Wittmer (2011) document that ESG reporting of Chinese companies increased from 4% in 2005 to 81.33% in 2009.[3] This makes a compound annual growth rate of 112.35% over four years. Corporations that publish ESG reports and have lower financial risks than their counterparts can achieve higher market returns. Auke, Rients and Bert (2008) discover a clear positive relationship between total ESG rating and operating performance.[4] A significant positive relationship is found between broader ESG factors and firm valuations, indicating that higher rated companies are associated with higher earnings multiples. These cases show that compared with non-ESG companies, ESG companies have better stock returns under the same risk. Moreover, ESG companies have the ability to resist carbon risks.

2.2 Carbon Emission Disclosure and Company Value

Carbon emission disclosure is a value-added for the investor. Chika and Tomoki (2014) find when firms harm the environment to achieve high profit, they can still maintain high performance if they can reduce pollution.[5] The company's active implementation of sustainable development strategies can add value and enhance the value of the company's social recognition. Anggraeni (2015) finds that disclosure of carbon emissions can increase company value and increase investor confidence. Hapsoro and Ambarwati (2018) also find that the more available information is in the carbon emissions disclosures will decrease the bid-ask spread and share price volatility and increase the trading volume.[6] Investors give positive responses to voluntary carbon emission disclosure because they believe that carbon emission information is vital to determine business sustainability. According to these scholars' researches, carbon emission disclosure can also increase financial performance. As a business ethic implementation, carbon emission disclosure improves the social trust of stakeholders, especially customers, to use environmentally friendly products. It can also improve firms' revenue, further increase firms profitability. Higher profitability leads to higher firm value.

2.3 The Impact of Financial Development on Carbon Emissions

As the financial system continues to deepen and financial development plays an increasingly important role in economic development, the concept of carbon finance has promoted the deep integration of the two industries of finance and carbon emissions. The impact of finance on carbon emissions has gradually expanded. Abbasi and Riaz (2015) find the development in the financial sector contributed towards an increase in emissions.[7] The stock market development eased the liquidity constraints faced by the listed firms, allowing them to expand output, increasing energy con-consumption and hence CO2

emission. Chia-Lin, Jukka, Hannu and Michael (2020) find the regression results suggest that when stock returns rise by 1%, CO2 emissions from coal combustion decreased by 9% among the countries included in the MSCI World Index.[8] Furthermore, when stock returns rise 1%, CO2emissions from oil combustion increase by 2%, but stock returns have no significant effect on CO2 emissions from gas combustion. Ralph and Alexander (2019) find that the increase in the size of the stock market has a significant negative impact on carbon dioxide emissions.[9] It is due to the decline in the relative growth rate of carbon-intensive industries and the reduction in carbon emissions per unit of output of carbon-intensive industries. Alam, Apergis, Paramati and Fang (2020) find stock market growth has a significant positive impact on clean-energy consumption, while they negatively affect the growth of CO2 emissions.[10].

2.4 Carbon Emission on Stock Return

As countries begin to pay more and more attention to changes in the environment and climate, many policies have been promulgated to support the development of ESG, which will impact the investment strategies of some investors and thus affect the stock return. Based on the US market's research on the impact of carbon emissions on stock prices, different scholars have different views. A recent study by Park and Monk (2019) on a different sample than ours finds that a portfolio with long stocks of companies with low carbon emissions and short stocks of companies with high emissions generates positive abnormal returns.[11] An early study by Prakash and Vera-Munoz (2014) show that S&P500 firms between 2006 and 2008 looks at the effects of direct carbon emissions on firm value. They find that higher emissions are associated with lower firm values.[12] Sautner and Vilkov (2020) have found that the uncertainty of climate policy is priced in the options market. Specifically, for carbon-intensive companies, the cost of option protection against downside tail risks is higher. When public attention to climate change surges, the cost of downside option protection will be magnified.[13].

However, some scholars have different opinions. Ilhan, Sautner, Vilkov (2021) find that stock returns are positively related to the level (and changes) of carbon emissions is largely consistent with the view that investors are pricing in a carbon risk premium at the firm level. Besides, they found that companies that successfully reduce emissions can provide lower stock returns, but companies that continue to burn more and more fossil fuels must give up providing higher returns.[14].

At present, there are a large number of studies expounding the relationship between ESG companies and stock returns. However, there is almost no research on the impact of carbon emission on company stock prices in the Chinese market. In 2021, China puts forward carbon neutrality strategy. National policies are the guidance of industrial development, and how much impact the proposed carbon emission policy will have on the development of traditional enterprises is worth demonstrating. Therefore, this article wants to explore the relationship between carbon emission and the company's financial situation and stock return before and after the proposed policy.

3 Data

3.1 Data Source

At present, there are a large number of studies expounding the relationship between ESG companies and stock yields. However, there is almost no research on the impact of carbon emission on company stock prices in the Chinese market. In 2021, China put forward the strategy of neutral carbon. National policies are the guidance of industrial development, and how much impact the proposed carbon emission policy will have on the development of traditional enterprises is worth demonstrating. Therefore, this article wants to explore the relationship between carbon emission and the company's financial situation and stock return before and after the proposed policy.

Let us talk about the research data of the paper. The primary data of the paper is the carbon emission and stock return. The carbon dioxide emissions scores in this article come from MSCI Index carbon footprint metrics. MSCI collect data from the most recent corporate resources. China is the country with the most carbon emissions globally, accounting for 30% of the world's carbon emissions. MSCI divide the company into 10 scores from 1 to 10. Lower carbon emission score represents worse performance in carbon emission, or higher carbon emissions. The carbon emission management score is to judge the company's response to climate change, including reducing emissions and the amount of gas burned, which reflects the company's acceptance of policies and management capabilities. The other primary data is Stock return and firm characteristics. The empirical analysis uses an extensive data set of monthly stock returns in China. The selected company stocks include various industries, and these stocks are listed on the Shanghai Stock Exchange or the Shenzhen Stock Exchange. These data come from the CSMAR, a research-based accurate database in the economic and financial field developed according to China's actual national conditions.

3.2 Hypothesis Development

Hypothesis 1

Companies with higher levels of carbon emissions (or faster growth in carbon emissions) have higher stock returns. There is a carbon premium in stock returns, and high-emission companies face greater carbon risks, so these companies will show higher stock returns. It means that stock returns are positively correlated with carbon emissions levels and changes. Patrick and Marcin (2020) think that investors demand compensation for their exposure to carbon emission risk. Hence, stocks of firms with higher total CO2 emissions and changes in emissions earn higher returns.[15] Harrison and Marcin (2009) prove the significant effects of social norms on markets by studying the investing environment of "sin" stocks. They find a significant price effect on the order of 15–20% from large institutional investors shunning sin stocks.[16].

Hypothesis 2

The second hypothesis is that companies with higher management carbon scores will have higher returns on stocks. Because under the same conditions, companies with

Table 1. Descriptive Statistics

Variable	(1) N	(2) mean	(3) Standard deviation
Stock return	15,752	0.494%	11.1%
Market value (in millions)	15,752	59.11	146.6
Carbon Emissions Score	15,904	5.398	2.424
Management Score	15,173	1.188	1.167

high management carbon credits indicate that they may have also taken measures to reduce their emissions by actively disclosing corporate carbon emissions to the public to enhance corporate social responsibility and improve corporate reputation, Increase investor confidence and increase stock returns. For companies that do not disclose the emission levels of all categories, the carbon premium is even greater.

Hypothesis 3
The third hypothesis is that companies with a larger market value are more susceptible to policy influences and receive more attention from the investment market. If these companies with the highest market value can manage carbon emission well, they will get a higher carbon emission management score. This will enhance the information of the investment market and increase the company's return on stocks.

4 Empirical Results

The result in the Table 1 show that the average company's monthly stock return equals 0.494%, with a standard deviation of 11.1%. The average company's market value is US$59.11 million. It can be seen from the carbon emission management score table that the stocks are divided into three groups monthly, the average management score is 1.118 and the average carbon emission score is 5.398. A company with good emission management can increase the company's stock return.

We will first explore the impact of carbon emission scores on stock returns. First, we sort out the carbon emissions scores of some stocks listed on the Shanghai Stock Exchange and Shenzhen Stock Exchange from 2017 to 2020, using the Fama-Macbeth cross-sectional regression test method to eliminate residuals. Then we analyse the relationship between stock returns and carbon emission scores, setting monthly returns as the dependent variable and regard carbon emission scores as the independent variable. The result is that the relationship between carbon emission scores and stocks is not statistically significant. In order to further explore whether the differences are significant, each month, the stocks are divided into three groups, five groups and ten groups, based on carbon emission score. Carbon emission score ranges from 1 to 10. Lower carbon emission score represents worse performance in carbon emission, or higher carbon emissions. According to the results are reported in Table 2, p value is 0.896, 0.988 and 0.902. When we sort stocks into 3 group, 5 group, and 10 group based on carbon emission score, respectively. The results indicate that there is no strong relationship between

Table 2. Carbon Emissions Score and Stock return

Variable	Carbon emission score (raw)	Carbon emission score 3 Group	Carbon emission score 5 Group	Carbon emission score 10 Group
Coefficient	0	0	0	0
Standard error	0.002	0.001	0.001	0.002
T-value	-0.01	-0.13	-0.02	-0.12
P-value	0.991	0.896	0.988	0.902
Constant	0.004	0.004	0.003	0.004
Observation	15736	15736	15736	15736
R-squared	0.016	0.012	0.015	0.015

carbon emissions scores and stock returns. Our results are different from Bolton and Kacperczyk (2020a, b) who find that document in the US market, stocks of companies with high carbon emissions have higher returns than companies with low carbon emissions.17 It shows that investors in the Chinese and US markets have different views on carbon emission scores. American investors believe that firms with more carbon intense business model has higher risks and they require higher compensation by holding such kind of stocks. In contrast, the impact of carbon emission score is quite limited in Chinese market, and the investors do not price in the carbon risks yet.

In addition, we regress stock return on carbon management score to explore the impact of management ability of carbon emissions on stock returns. Carbon management score is different from carbon emission score. Carbon management contain three steps. Firstly, company measure carbon emissions and know the carbon footprint. And then companies need to analyse emissions data and set carbon reduction strategy to reduce emissions from daily operations. Lastly, companies try to offset the rest to attain a carbon neutral status.

Use the same method as detecting carbon emission score, we find that p-value is equal to 0.06 in Table 3, significant at 10% level, showing stock return is higher when the firms could better manage their carbon emissions.

To further explore their relationship, then these stocks are sorted into 3 groups, 5 groups, and 10 groups, based on carbon emission management score, respectively. The results are reported in Table 4 is that p value is 0.017, 0.027 and 0.02. The results indicate that there is strong relationship between carbon emissions management scores and stock returns. Besides, a company with good carbon emission management scores can promote the growth of the company's stock value. Some companies have high carbon emissions due to the nature of their industry. If they can manage their carbon emissions well, investors are confident to buy the company's stock, and this contribute to increasing the company's stock returns.

High-carbon and high-emission companies generally have larger market capitalization and are more affected by policies. They are also the main targets of carbon neutrality strategies. Achieving carbon peak and carbon neutrality, and moving towards zero carbon

Table 3. Market capitalization carbon management score and stock return (Raw)

Variable	small market capitalization management score	large market capitalization management score
Coefficient	0.086	0.268
Standard error	0.090	0.094
T-value	0.95	2.86
P-value	0.345	0.006
Constant	-0.008	0.003
Observation	7758	7758
R-squared	0.016	0.024

Table 4. Management score and stock return

Variable	Carbon emission manage score (raw)	Carbon emission manage score 3 Group	Carbon emission manage score 5 Group	Carbon emission manage score 10 Group
Coefficient	14%	0.3%	0.2%	0.1%
Standard error	0.002	0.001	0.001	0.002
T-value	1.93	2.46	2.28	2.41
P-value	0.657	0.017	0.027	0.020
Constant	0.004	0.003	0.002	0.001
Observation	15029	15029	15029	15029
R-squared	0.012	0.001	0.010	0.010

and net carbon emissions requires the development of energy-saving emission reduction plans for such companies. Therefore, we want to explore if large market capitalization companies can manage carbon emissions well, and whether they can have a greater positive impact on stock returns. The stocks are divided into large market capitalization portfolios and small market capitalization portfolios according to market capitalization. The impact of carbon emission management scores of companies with large market capitalization and small market capitalization on stock returns is studied. The regression result is reported in Table 5 shows that the p-value of small market capitalization companies is $0.345 > 0.1$, does not have a significant level, while the p-value of a large market capitalization company is equal to $0.006 < 0.01$, indicating significance at a 99% confidence level. If a company with a high market capitalization manages its carbon emissions well, this will increase the company's stock return. The correlation with the stock return is 26.8%, which has a more significant impact on stocks, indicating that larger companies should pay more attention to carbon emissions management.

Table 5. Market capitalization carbon emission score and stock return (Raw)

Variable	small market capitalization emission score	large market capitalization emission score
Coefficient	0.001	0.001
Standard error	0.001	0.001
T-value	0.45	-0.5
P-value	0.345	-0.5
Constant	-0.007	0.012
Observation	7772	7772
R-squared	0.015	0.018

5 Conclusion

How carbon emission scores affect stock returns? This is an important question for the soaring field of climate change and finance. This is also a basic problem for the governor of the country. In this paper, we solve this question by undertaking a cross-sectional stock returns analysis with carbon emissions score and carbon emission management score as a firm characteristic. The result shows that good management of carbon emissions has a positive effect on the growth of the company's stock return. At the same time, companies with high market capitalization can get a higher stock return, if they can take effective plans to manage the company's carbon emissions.

The Organization for Economic Cooperation and Development (OECD) put forward the concept of "Transition Finance" in 2019, which refers to financial activities that provide financing to help economic entities in their transition to the Sustainable Development Goals. To promote China's next economic transformation and green development needs, China actively promotes the implementation of the dual-carbon policy. On the one hand, it must vigorously promote the development of green and low-carbon industries, and on the other hand, it must support the low-carbon transformation of carbon-intensive industries. The realization of the double-carbon goal depends on the optimization and upgrading of the industrial structure and technological innovation.

In the future, the carbon market will become more perfect. The proposed carbon neutral strategy has promoted the development of green financial investment and has become an important guide for green financial institutions to develop green financial services. More diversified investment methods will emerge at home and abroad to further promote the development of the green financial market.

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