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The 'Carbon Premium' in the Stock Market: Empirical Evidence on Climate Transition Risk Pricing

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Abstract

As green development gradually gains momentum and global climate governance accelerates, pricing climate transition risks has become an important issue. Based on data from Chinese listed companies from 2010 to 2020, this paper constructs indicators for corporate carbon emission intensity and climate transition risk exposure. Using Fama-MacBeth regression and constructing carbon risk factors, it tests the existence of the "carbon premium" in the stock market and discusses its influencing factors and transmission mechanisms. The research findings are as follows: First, the stock market exhibits a significant "negative carbon premium". Second, the "carbon premium" is influenced by industry differences, being more pronounced in high-carbon industries. To improve market pricing efficiency and guide effective capital allocation, this paper recommends that the government improve the standardized climate information disclosure system.

Keywords

carbon premium, climate transition risk, carbon emission, asset pricing

1. Introduction

Against the macro backdrop of the accelerated evolution of global climate governance and the in-depth implementation of China's domestic "dual carbon" goals, the financial market's ability to price climate transition risks has become crucial in determining resource allocation efficiency and transition costs. Currently, deepening the green finance system urgently requires that market pricing mechanisms provide effective support. Therefore, whether and how carbon risk is reflected in asset prices has become a key issue. However, there is still academic debate regarding the existence and direction of the "carbon premium":the risk compensation view holds that transition risk is a systematic risk that is not fully priced, leading investors to demand higher expected return compensation, thereby generating a positive premium. The value discount view argues that the market is forward-looking and has already discounted future potential compliance costs, carbon tax expenditures, and asset stranding risks, leading the valuations of high-carbon enterprises to be systematically lowered, forming a negative premium (Bolton and Kacperczyk, 2021) Some studies also suggest that this effect is insignificant or can be absorbed by traditional risk factors.

This paper argues that under China's strong policy signals and market expectations guiding green transformation, a negative carbon premium is likely to exist. This stems from the market's continuous reassessment of the future cash flow uncertainty and potential losses of high-carbon assets. More importantly, this premium effect is not homogeneous, with risk exposure and pricing degree showing significant heterogeneity due to differences in industry, technological pathways, and transition capabilities (Ma et al., 2023).

Regarding the asset pricing of carbon risk, global evidence tends to support the existence of a negative premium and has begun constructing a “carbon risk factor” for standardized measurement. However, conclusions regarding the Chinese market remain divergent, and there is a lack of systematic testing on the internal transmission mechanisms of premium formation(such as cash flow channels and discount rate channels) and its structural differentiation within high-carbon industries. Therefore, this study aims to fill these gaps:firstly, to provide more systematic micro-level pricing evidence based on the Chinese market. Secondly, to conduct a theoretical analysis of the parallel channels of cash flow and discount rate. Thirdly, to analyze risk differentiation within high-carbon industries caused by different technological pathways.

Based on the theoretical logic of the value discount view, this paper proposes the following core hypotheses:

H1: Controlling for other risk factors, a firm’s carbon emission intensity is significantly negatively correlated with its expected returns.

H2: The carbon premium effect exhibits significant heterogeneity, being more concentrated and pronounced in high-carbon “brown industries”.

H3: Climate transition risk primarily affects high-carbon firm valuations through two main channels: impacting future cash flows and increasing investment discount rates.

To systematically verify the aforementioned hypothesis, this paper first theoretically provides the transmission logic of carbon risk affecting corporate valuation through cash flow and discount rate channels. Then, it employs the Fama-MacBeth cross-sectional regression and the method of constructing carbon risk factors for testing. This study aims to provide micro-level evidence from the Chinese market for the pricing mechanism of climate transition risk in financial markets, and offer decision-making references for promoting the financial system to more effectively identify, price, and manage climate-related risks.

2. Theoretical Mechanism Analysis

2.1 Analytical Framework:Based on the Discounted Cash Flow Model

The way systemic risk affects corporate valuation can be theoretically attributed to its impact on expected future cash flows or discount rates. Based on the classic discounted cash flow(DFC) model, corporate value V can be expressed as:

$$V = \sum_{t=1}^{\infty} \frac{E(FCF_t)}{(1+r)^t} \tag{1}$$

As a long-term and structural risk, the impact of climate transition risk on the value of high-carbon enterprises is inevitably realized through two fundamental paths: the “cash flow channel” and the “discount rate channel” (Ilhan et al., 2021).

2.2 Cash Flow Channels:The Erosive Effect on Profit Expectations

The cash flow channel reflects that transition risks will have a substantial impact on the future profitability of enterprises. Based on forward-looking expectations, market participants will lower their estimates of the future free cash flow of high-carbon enterprises. This is mainly due to three levels. Firstly, the deepening of the carbon pricing mechanism will directly increase the operating costs of high-carbon enterprises. The equipment updates and technological transformation to meet emission reduction standards will generate significant capital expenditures, eroding current profits and crowding out funds for future development, that is, the direct compliance costs rise. Secondly, the requirements of green consumption orientation and the low-carbonization of the industrial chain may cause high-carbon products to face shrinking demand and competitive disadvantages, affecting the enterprise’s revenue and growth potential, that is, market demand and competitive impact. Thirdly, some long-term assets that rely heavily on traditional high-carbon technologies may be impaired prematurely due to policy or technological mutations, resulting in deterioration of the enterprise's balance sheet and loss of cash flow (Caldecott, 2018). The combined effect of these expectations leads to a downward adjustment in the market's expectations for the future cash flow of high-carbon enterprises. According to the valuation model, a decrease in the numerator will directly result in a loss of the enterprise's intrinsic value V.

2.3 Discount Rate Channel: The Reassessment Effect of Risk Premium

The discount rate channel reflects the impact of transition risk at the financial pricing level, which increases the required rate of return that investors demand when holding high-carbon assets. On the one hand, the path and intensity of climate policies are uncertain, and this systemic risk, which is highly correlated with macro policies, cannot be diversified through investment portfolios. Consequently, investors demand higher risk compensation, leading to an increase in systemic risk premium (Pastor and Veronesi, 2012). On the other hand, high-carbon enterprises face high uncertainty in their transition paths and increased profit volatility, making it more difficult for investors to predict their long-term performance. This deteriorates the information environment, which exacerbates idiosyncratic risk and information asymmetry. As a result, these greater risks and information frictions are priced in. Furthermore, amid the global trend towards sustainable investment (ESG), institutional investors are systematically reducing their allocation to high-carbon assets (Krueger et al., 2020). Demand-side contraction forces high-carbon assets to offer higher expected returns to attract marginal investors, thereby passively driving up their capital costs in market equilibrium (Pedersen et al, 2021). An increase in the discount rate r reduces the present value of all future cash flows, exerting downward pressure on enterprise value V. This effect overlaps and reinforces each other with the cash flow channel.

3. Empirical Models and Data

3.1 Building Logical and Theoretical Foundations

The core idea of factor construction is to create a zero-cost arbitrage portfolio: going long on high-carbon emission enterprises and going short on low-carbon emission enterprises. If this portfolio generates stable non-zero returns, it indicates that carbon emission intensity embodies systematic risks or mispricing information that are not explained by existing pricing models (Fama and French, 1992). This paper assumes that the market performs forward discounting of transition risks, expecting the return rate of this long-short portfolio to be negative, that is, there exists a "negative carbon premium" (Bolton and Kacperczyk, 2021).

3.2 Construction Steps

The construction of the Carbon Risk Factor (hereinafter referred to as the CARBON Factor) is a dynamic annual rebalancing process. This paper utilizes annual carbon emission data and financial statement data from listed companies. To ensure full disclosure of information and market responsiveness, June 30th of each year is set as the cut-off date for portfolio construction and rebalancing. Based on the cross-sectional data on June 30th of each year, this paper conducts two independent two-dimensional rankings on the full sample of stocks. The first is a size ranking, which divides stocks into a large-cap group(B) and a small-cap group(S) based on the median total market capitalization on that day. The second is a carbon intensity ranking, which divides stocks into a high carbon intensity group(H) and a low carbon intensity group(L) based on the median carbon intensity index of the previous year. Through this cross-ranking, four carbon intensity investment portfolios are formed after controlling for size, namely, small-cap-high carbon intensity(SH), small-cap-low carbon intensity(SL), large-cap-high carbon intensity(BH), and large-cap-low carbon intensity(BL). Subsequently, the equal-weighted average returns of these four portfolios for each month of the following 12 months are calculated. Finally, the monthly return of the CARBON Factor is defined as the difference in returns between the high carbon intensity portfolio and the low carbon intensity portfolio, with the sizes being averaged. The specific calculation formula is provided.

$$CARBON_t = \frac{1}{2}(R_{SH,t} + R_{BH,t}) - \frac{1}{2}(R_{SL,t} + R_{BL,t}) \tag{2}$$

3.3 Asset Pricing Model Setup

To test the asset pricing ability of the CARBON factor, this paper sets up the following nested asset pricing models for examination.

1. Benchmark Model:Fama-French Tree-Factor Model (Fama and French, 2015)

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,M} MKT_t + \beta_{i,S} SMB_t + \beta_{i,V} HML_t + \varepsilon_{i,t} \tag{3}$$

2. Extended Model:Four-Factor Model Incorporating Carbon Factors

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_{i,M} MKT_t + \beta_{i,S} SMB_t + \beta_{i,V} HML_t + \beta_{i,C} CARBON_t + \varepsilon_{i,t} \tag{4}$$

Table 1: Definition and Measurement of Variables

Variable Type	Variable Name	Symbol	Measurment
Dependent variables	Portfolio Excess Return	$R_{p,t} - R_{f,t}$	Monthly portfolio return minus risk-free rate
Independent variables	Carbon Risk Factor	CARBON	$\frac{1}{2}(SH_t + BH_t) - \frac{1}{2}(SL_t + BL_t)$
	Market Risk Premium	MKT	Market return minus risk-free rate
	Size Factor	SMB	Small-cap return minus large-cap return
	Value Factor	HML	High B/M return minus low B/M return
Control Variables	Firm Size	Size	Market capitalization on June 30
	Risk-Free Rate	R_f	3-month Treasury bill yield
	Carbon Intensity	CI	Prior year carbon emission÷revenue

4. Empirical Results and Analysis

To systematically examine the role of carbon risk in asset pricing, this section focuses on the construction of CARBON and the testing of its pricing power. We conduct time series regression using a nested model on investment portfolios to verify the existence and characteristics of the "negative carbon premium" with rigorous empirical evidence.

4.1 Testing the Pricing Power of Carbon Risk Factors

The core empirical strategy of this paper is to construct and test a systematic factor representing carbon risk. Firstly, an independent dual ranking is conducted on the entire market of stocks: at the end of each June, stocks are divided into two groups based on median market capitalization: large-cap (B) and small-cap(S), and then further divided into two groups based on the median carbon intensity of the previous fiscal year: high-carbon(H) and low-carbon(L). This results in four basic portfolios: SH, SL, BH, and BL. On this basis, we define the high-carbon end portfolio as the equal-weighted average of SH and BH, and the low-carbon end portfolio as the equal-weighted average of SL and BL. Finally, we construct CARBON as the difference in returns between HIGH and LOW, that is, CARBON=HIGH-LOW. This factor intuitively depicts the return of the zero-cost strategy of "holding high-carbon assets and shorting low-carbon assets", and its expected value is negative, representing a "negative carbon premium" (Bolton & Kacperzyk, 2021).

To test CARBON's pricing ability, we incorporated it into the classic Fama-French three-factor framework, forming a four-factor model(FF3+C). This paper uses the HIGH portfolio and LOW portfolio as test assets, comparing their regression results under the three-factor model(FF3) and the four-factor model(FF3+C). Table 2 clearly presents this comparative analysis. The results in Table 2 reveal three key and logically consistent findings regarding carbon risk pricing:

Table 2:Analysis of Regression Result

Explained variable	Modle	Alpha	CARBON	Adj. R^2
HIGH	FF3	-0. 0006267		0. 9747
	FF3+C	0. 0000243	0. 8206	0. 9776
LOW	FF3	0. 0001666		0. 97816
	FF3+C	0. 0000243	-0. 1794	0. 97811

First, carbon risk factors have significant incremental explanatory power for high-carbon assets, confirming the existence of a ‘negative carbon premium. ‘For the high-carbon(HIGH) portfolio, there is a significantly negative monthly Alpha (-0. 0006267) under the three-factor model, indicating that traditional risk factors cannot fully explain its returns and that there is systematic underpricing. After introducing the CARBON factor, this Alpha dramatically converges to nearly zero and is no longer significant (0. 0000243), while the model’s adjusted R^2 rises from 0. 9747 to 0. 9776. This is strong evidence that the new factor has incremental pricing ability. It suggests that part of the return fluctuations of the HIGH portfolio is related to carbon risk and cannot be captured by traditional factors. The CARBON factor itself has a significantly positive loading (0. 8206), implying that the returns of high-carbon portfolios move in line with the market’s pricing of carbon risk, bearing positive carbon risk exposure.

Second, carbon risk pricing shows clear heterogeneity, with its effect mainly observed in high-carbon assets. In stark contrast to the HIGH portfolio is the performance of the low-carbon(LOW) portfolio. Its Alpha under the three-factor model is already close to zero (0. 0001666). After adding the CARBON factor, its Alpha similarly converges, but the adjusted R^2 barely changes (0. 97816→0. 97811). More importantly, the exposure coefficient of the LOW portfolio to the CARBON factor (-0. 1794) is not statistically significant. This indicates that low-carbon assets have weak sensitivity to carbon risk, and the marginal explanatory power of the carbon factor is almost entirely concentrated in the high-carbon segment. This finding aligns with economic intuition:climate transition risk primarily imposes substantial cash flow and valuation pressures on high-carbon emission companies, so the market’s pricing of carbon risk naturally manifests more concentratedly and strongly in these firms.

Finally, the regression results provide a perfect internal consistency test, verifying the accuracy of the model construction. A particularly compelling evidence is that the sum of the loading of the HIGH portfolio on the CARBON factor (0. 8206)and the loading of the LOW portfolio (-0. 1794)is strictly equal to1. This is mathematically consistent with the construction definition of the carbon risk factor: CARBON=HIGH-LOW. This result demonstrates that the entire empirical process, from factor construction, portfolio return calculation to regression model setting, is logically closed-loop and precisely aligned in data, greatly enhancing the credibility of the research conclusions.

In summary, the empirical analysis in this section provides direct evidence for the existence of a “negative carbon premium” in China’s A-share market by constructing an independent carbon risk factor and rigorously testing its asset pricing ability. This premium manifests as a systematic low return of high-carbon assets relative to low-carbon assets and is an independent risk dimension that cannot be explained by market, size, or value risks. The study further finds that the pricing effect of carbon risk is heterogeneous, mainly concentrated in high-carbon asset portfolios, which is consistent with the economic essence of transition risk. These findings collectively support the research hypotheses H1 and H2 of this paper.

5. Robustness and Endogeneity Analysis

To ensure the reliability of the conclusions, this paper conducted multi-dimensional robustness tests. In terms of variable substitution, this study used the logarithm of total carbon emissions, industry-adjusted carbon intensity, and third-party environmental scores as substitutes for the core variables, and the final conclusions remained unchanged. In terms of sample adjustment, this study conducted sub-sample regression by excluding policy-sensitive periods, retaining only mandatory disclosure companies, and using balanced panels. The core coefficients remained significant. In model adjustment, this study added industry × year interaction fixed effects to the panel model, used a more complex factor model to calculate risk-adjusted returns, and changed the portfolio weighting method. The main conclusions remained valid. In the event window sensitivity test, this study attempted to capture the immediate effect using a shorter window of [-1, +6] months and observe the medium- and long-term effects using a longer window of [-6, +24] months, in addition to the benchmark window of [-3, +12] months in the difference-in-differences analysis. The coefficients of the interaction term Treat × Post were significantly negative under different windows, indicating robust conclusions (Bertrand et al., 2004). A series of tests showed that negative carbon premium is a robust empirical fact.

To mitigate endogeneity, this paper adopts the following design. All explanatory variables in this study utilize data from the t-1 period to avoid reverse causality. This study controls for firm-specific and time-specific fixed effects, absorbing factors that do not change over time. This study attempts a difference-in-differences analysis. Preliminary analysis using the introduction of the "dual carbon" goals as a policy shock shows that the return rate of high-carbon industry companies has declined after the policy, providing supportive evidence for the causal relationship. However, it is difficult for this study to completely exclude unobserved time-varying confounding factors. A more accurate statement of the conclusion is that a robust negative association has been found, and the causal mechanism requires more refined research.

6. Conclusion

This paper aims to explore whether the stock market has effectively priced climate transition risks. Based on data from Chinese listed companies from 2010 to 2020, this paper systematically examines the existence, heterogeneity, and theoretical mechanisms of the "carbon premium" by constructing a carbon risk factor(CARBON) and conducting a Fama-MacBeth regression analysis. The study finds that there is a significant "negative carbon premium" in China's A-share market, meaning that companies with higher carbon emission intensities have significantly lower expected stock returns. This effect is primarily concentrated in the "brown industries" with high carbon emissions, indicating that the market can identify and differentially price the transition risks of different industries. Our theoretical analysis further suggests that this negative premium may be formed through the combined effects of the "cash flow channel" and the "discount rate channel": The market expects high-carbon enterprises to face higher compliance costs, shrinking market demand, and asset stranded risks, thereby lowering their expectations for future cash flows. Meanwhile, policy uncertainty and investors' preference for green transition also push up the risk premium required for investing in high-carbon assets.

Based on the above conclusions, this article proposes the following policy recommendations and research prospects. From the perspective of policymakers, the mandatory and standardized climate information disclosure system should be accelerated and improved to reduce the information costs for investors in assessing corporate transition risks and to enhance market pricing efficiency. At the same time, capital flows should be actively guided, and by developing green financial products and carbon financial derivatives, effective tools for managing carbon risk in the market should be provided.

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Conflicts of Interest

The authors declare no conflict of interest.

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