Financial Engineering and Risk Management (2023)
Clausius Scientific Press, Canada
DOI: 10.23977/ferm.2023.061102
ISSN 2523-2576 Vol. 6 Num. 11

Impact of Carbon Prices on Stock Returns: Evidence from China's High-Carbon Industries

Bo Xiao[1,*], Yimeng Ren[2]

[1]*School of Business, Ningbo University, Ningbo, 315211, China*
[2]*School of Internet of Things Engineering, Jiangnan University, Wuxi, 214122, China*
[*]*Corresponding author: 17858940731@163.com*

Keywords: Carbon trading, green finance, stock returns, Fama-French three-factor model, high-carbon industries

Abstract: Carbon trading is a key tool in the financial sector's shift towards a sustainable model in response to climate change, which is a market-based approach to regulating greenhouse gas emissions. This paper examines the impact of carbon prices on stock returns. The study utilizes an improved three-factor model and data from 40 stocks in China's high-carbon industries, as well as a control group of 80 stocks from other industries. The empirical findings reveals that high-emitting companies are negatively affected by carbon trading prices, leading to lower stock returns. This suggests that the impact of carbon trading prices on costs and investor confidence outweighs the carbon risk premium. However, the results differ for industries in the control group, indicating that the conclusions may not apply universally.

1. Introduction

Promoting a green financial sector is no longer a mere aspiration but a necessity to ensure the longevity of our global economy within the constraints of our planet's ecological boundaries. The circular economy, which emphasizes the reduction, reuse, and recycling of resources, is gaining traction as a viable model for sustainable growth. As the world grapples with the challenges of climate change, the financial sector is increasingly recognizing the need to transition towards a more sustainable model. A pivotal instrument in this transition is carbon trading, a market-based approach to controlling greenhouse gas emissions. One of the critical aspects that has garnered attention, but remains insufficiently studied, is the impact of carbon trading prices on the firms dependent on energy. Given the significant market power exhibited by high emitters in certain economies, understanding this relationship becomes crucial for investors, policymakers, and stakeholders alike. In this research, we seek to shed light on the nuances of how carbon trading prices can serve as a barometer for the valuation of high-carbon stocks through a comprehensive empirical analysis, thereby offering insights into the broader implications for the green finance sector.

This paper posits that carbon trading prices significantly influence the asset pricing of high-carbon firms. This influence can be dissected from various angles. From the perspective of investors, the modern investor is increasingly attentive to the environmental, social, and governance (ESG) metrics of companies. When a firm faces economic strain due to escalating carbon trading prices, it may be perceived as having an insufficient strategy to combat climate change. This perception can deter potential investments, leading to a decline in the company's stock value. Posteriorly, for industries heavily reliant on energy, a surge in carbon trading prices translates to a rise in the cost of carbon emissions. This added cost can erode the profit margins of companies predominantly dependent on fossil fuels, consequently diminishing the appeal of their stocks. Conversely, firms that innovate and offer low-carbon solutions might find themselves with a competitive edge in the market. Finally, as carbon trading prices ascend, there's an industry-wide nudge towards adopting greener, low-carbon production methodologies. Transitioning to such methods often demands significant capital and time. Moreover, the success of these transitions isn't guaranteed. This inherent uncertainty amplifies a company's risk profile, which in turn can sway the asset risk premium of its stocks. In summation, fluctuations in carbon trading prices play a pivotal role in shaping investor perceptions, determining cost structures, and guiding the business strategies of high-carbon firms. These factors collectively influence the equity returns of such companies.

This paper is divided into two main sections: a literature review and an empirical analysis. The literature review section provides an overview of recent research on asset pricing theory, with a particular focus on the application and development of asset pricing models in the context of green finance. The empirical analysis section collects data on carbon trading prices, three-factor model data, and stock returns of 15 listed energy companies in China over the past decade. The pricing ability of carbon trading prices is then examined.

2. Literature review

2.1 The Development of Asset Pricing Model

The Asset Pricing Theory, a significant branch of finance, primarily investigates how the value of financial assets is determined. Harry Markowitz proposed the Modern Portfolio Theory (MPT) in 1952, emphasizing the trade-off between risk and return and introducing the concept of the efficient frontier. This theory laid the foundation for subsequent asset pricing theories. During the 1960s to 1980s, several classic asset pricing theories were successively introduced, including the Capital Asset Pricing Model (CAPM), which explains the relationship between expected asset returns and market systematic risk, the Arbitrage Pricing Theory (APT), which explains asset prices through risk-free arbitrage opportunities, and the Consumption Capital Asset Pricing Model (CCAPM), which emphasizes the interrelationships between consumption and investment decisions. The rise of behavioral finance after the 1990s has challenged the traditional assumption of rational investors. Behavioral finance emphasizes the role of psychological factors and irrational behavior in asset pricing, providing a new perspective for understanding the volatility of asset prices. Luo et al. conducted an empirical analysis to examine the impact of investors' irrational sentiment and behaviors on the asset risk premium [1]. Utilizing daily frequency data from January 2014 to September 2019 for the CSI 300 index, they observed a significant positive influence of investor sentiment and institutional crowded-trade behavior on stock premium.

In recent years, multi-factor models have gained prominence as a key approach to asset pricing. These models identify various risk factors that affect asset returns, including market risk, size factors, value factors, among others. By incorporating multiple factors, these models offer investors more sophisticated tools for risk management. Zhang et al. studied the determinants of the risk premium in the Shanghai and Shenzhen A-Share market [2]. They developed a regression model based on a proposed ten-factor model and utilized the BJS method. Their findings revealed that the long and short-term spread and money supply exerted significant explanatory effects on the stock risk premium. These results provided a valuable supplement to the traditional three-factor model. Lin et al. introduced monetary policy uncertainty (MPU) as a pricing factor in asset pricing models [3].

Employing the stochastic discount factor model, they found a significantly positive coefficient for the MPU factor pricing kernel, indicating its importance in pricing assets in China's stock market. Moreover, the risk premium was significantly negative, suggesting that MPU influences asset prices. Xu et al. investigated the impact of economic growth and inflation on asset pricing models in the Chinese market [4]. They developed an asset pricing model conditional on macroeconomic conditions. Their results demonstrated that the proposed model significantly enhanced the pricing power of the traditional Capital Asset Pricing Model (CAPM) in China's capital market.

2.2 Application of Asset Pricing in Green Finance

Green finance, a field that explores the interplay between climate change and finance, has emerged as a crucial frontier in academic research on finance. Chen et al. conducted a comprehensive analysis of climate risk and asset prices, drawing on both theoretical models and empirical evidence [5]. Castro et al. examined the influence of environmental performance on stock prices using a dataset comprising 2638 firm-year observations from 16 European countries during the period 2005-2017 [6]. They discovered that investors perceive renewable energy policies and the potential transmission effect of technology as counterbalancing factors that offset the positive impact of carbon performance on a firm's value. Motivated by the rise of socially responsible investment practices in mainstream investment activities, Tiwari et al. employed the TVP-VAR approach to investigate the interconnectedness and spillover effects of green bonds, carbon prices, and renewable energy stocks, utilizing daily data spanning from January 4th, 2015 to September 22nd, 2020 [7].

Scholars have also introduced climate factors and corporate environmental performance into asset pricing models. Pedersen et al. put forth a theoretical framework that incorporates the environmental, social, and governance (ESG) scores of individual stocks and utilizes an ESG-adjusted capital asset pricing model to determine equilibrium asset prices [8]. The researchers tested this theory by employing proxies derived from several large datasets for prediction purposes. In an effort to assess whether investors require a risk premium when transitioning to low emission firms, Mirza et al. conducted a study using a time series sample of firms from six GCC countries spanning the years 2011 to 2020 [9]. They introduced an emission-based risk factor into the conventional asset pricing framework. The findings of their study suggest that carbon emissions are systematically factored into stock returns. Bouri et al. employed textual-based climate policy uncertainty index to provide empirical evidence regarding the predictive nature of climate policy uncertainty in the price dynamics of green and brown energy equity [10]. Moreover, they emphasized the influence of climate policy uncertainty on investor preferences for green energy stocks, which holds significance for asset pricing and style rotation strategies.

2.3 Research on Carbon Trading in Financial Field

Using the Shenzhen pilot as an example, Wen et al. quantitatively analyzes the impact of carbon emissions regulation on stock returns using a difference-in-differences (DID) method [11]. The findings indicate that the establishment of China's carbon emissions trading market has a positive effect on the excess returns of participating companies, with an increasing carbon premium in stock returns. Wang et al. examines the impact of China's carbon emissions trading scheme on the market power of high-carbon enterprises using panel data from 2009 to 2019 [12]. The results show that the implementation of the ETS led to a 26.99% decline in the market power of high-carbon enterprises. The negative impact on market power is mainly attributed to a reduction in horizontal integration rather than vertical integration. In general, previous research on green finance and asset pricing has provided many valuable insights for future researchers. However, the impact of carbon trading prices on equity returns of high-carbon firms remains an underexplored area. Through this research, we seek to contribute to the understanding of the role of carbon trading prices in asset pricing, particularly in the context of high-carbon firms.

3. Method

3.1 Data

In this research, we utilize data from 40 relevant stocks belonging to China's eight high-carbon industries (namely, package, petrochemical, chemical, cement, steel, nonferrous metals, electricity, and aviation) obtained from the constituents of the CSI 500 index. Simultaneously, a control group consisting of 80 randomly selected stocks from other industries was included. Moreover, we incorporate the trading prices from various major carbon emissions markets in China, namely Beijing, Shanghai, Guangdong, and Shenzhen. Both stock returns and carbon prices are derived from Wind Database. In the following section, we will introduce the three-factor model and its construction methodology. The data required for factor construction are sourced from the China Stock Market & Accounting Research Database. Given that China's attempt to establish a carbon emissions trading system began in 2013, the research period spans from June, 2013, to July, 2023, and all data used are monthly frequency data.

3.2 Construction of improved Three-Factor Model

To explain the excess returns of portfolio ($R_{i,t} - R_f$), the Fama and French Three-Factor Model incorporates several factors, including the excess market returns, as well as factors pertaining to size and book-to-market equity ratio [13]:

$$R_{i,t} - R_f = a_i + b_i\left(R_{M,t} - R_f\right) + s_i SMB + h_i HML + e_{i,t} \tag{1}$$

To evaluate the influence of carbon emissions exchange on stock returns of high-carbon enterprises, we propose incorporating carbon trading prices as an additional factor. This inclusion is motivated by our analysis in the introduction, as well as relevant previous research [14]. The modified model is presented as follows:

$$y_{it} = \alpha + \beta CTP_{it} + Control_{it} + Trend + k_t + \mu_i + \varepsilon_{it} \tag{2}$$

In equation (2), y_{it} represents the abnormal return of the stock for company i in month t. The company fixed effects μ_i account for the persistent heterogeneity across companies, while the year fixed effects k_t control for shocks specific to each year. The $Control_{it}$ variables encompass the monthly excess return ($R_{M,t} - R_f$) of the market portfolio, the "small-minus-big" size factor SMB_t, and the "high-minus-low" value factor HML_t, as proposed by Fama and French (2004, 2006). The abbreviation CTP stands for carbon trading price. Subsequently, we will employ data on stock returns of high-carbon listed enterprises to empirically evaluate the efficacy of this newly proposed model.

Table 1: Table of correlation coefficient between five factors

	MKT	SMB	HML	RMW	CMA
MKT	1				
SMB	0.260	1			
HML	-0.207	-0.354	1		
RMW	-0.355	-0.866	0.237	1	
CMA	-0.110	0.272	0.613	-0.398	1

Table 2: Table of correlation coefficient between four factors

	MKT	SMB	HML	CTP
MKT	1			
SMB	0.260	1		
HML	-0.207	-0.354	1	
CTP	0.066	-0.197	-0.114	1

It is worth mentioning that initially in this study, we intended to employ the five-factor model proposed by Fama and French (2014). However, we observed a strong negative correlation between the SMB and RMW factors, as shown in Table 1. In order to avoid financial interpretations that may be deemed unreasonable due to this correlation, we opted to use the three-factor model instead. The coefficients of the factors in the model are presented in Table 2, indicating the absence of significant multicollinearity among the explanatory variables.

4. Experimental Analysis

4.1 Trend of Emissions Trading Prices

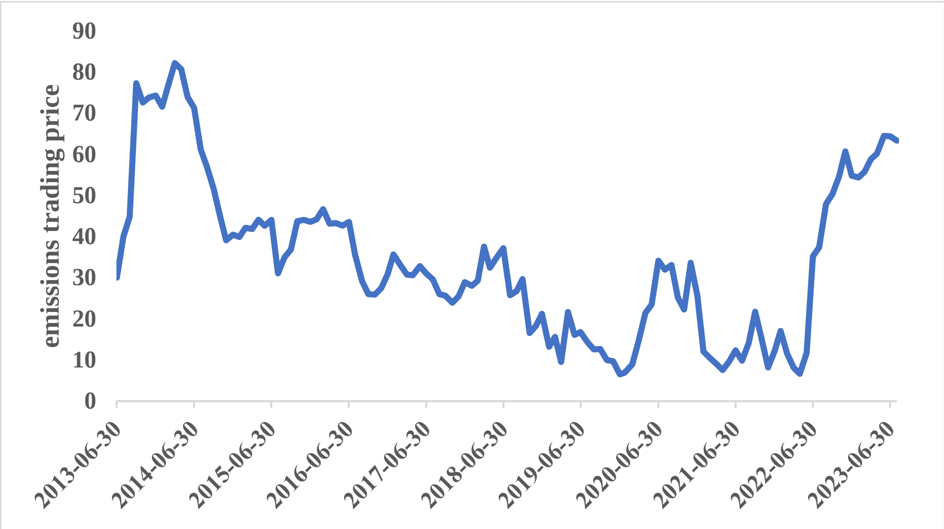

Figure 1: Price on emissions trading over the past ten years

We calculated the weighted average trading prices of several major emissions trading systems in China based on trading volume. By observing the trend of trading prices in Figure 1, it is evident that although prices were initially high when the emissions trading systems were established, they have been declining steadily until early 2020. This downward trend reflects changes in the balance of supply and demand, indicating a reduction in high-emitting companies and an increase in clean companies in terms of quantity. This change in market structure signifies the effectiveness of emissions trading systems as an environmental governance tool. However, starting from late 2021, emissions trading prices have shown an upward trend, possibly due to the following reasons. As China has set the goal of reducing carbon emissions in two phases, there has been an increased demand from society for accelerated carbon emission reductions from businesses. In the absence of matching levels of green technological innovation, the demand for carbon emission rights has surged.

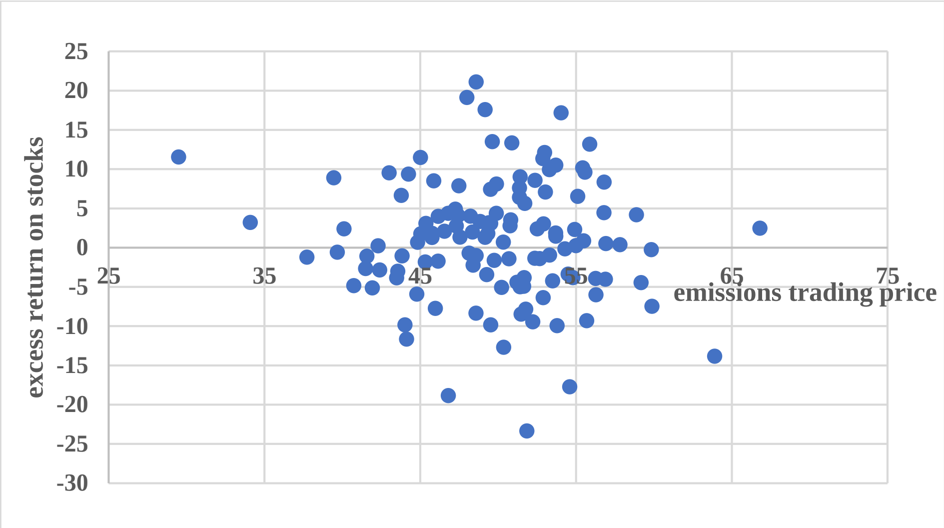

Figure 2: Scatter plot of stock returns against emissions trading prices

To further explore the green finance attributes of emissions trading systems, we plotted a scatter plot of stock returns of high-emitting companies against emissions trading prices (outliers have been removed). The emissions trading prices may have a negative impact on the profitability of companies by influencing their environmental governance costs. While Figure 2 roughly captures this relationship, it still requires empirical testing and verification.

4.2 Impact of Carbon Price on Stock Return

Table 3: Test results of the impact of emission trading prices on stock returns

	dependent variable: $R_i - R_f$	
	experimental group	control group
constant	-0.362	-0.922
	(-0.107)	(-0.201)
$R_M - R_f$	98.442***	96.127***
	(6.370)	(6.045)
SMB	39.565	45.901*
	(1.371)	(1.650)
HML	67.638***	42.411*
	(2.676)	(1.710)
emissions trading price	-0.338*	-0.102
	(-1.676)	(-0.528)
Trend	-0.092	-0.041
	(-0.373)	(-0.232)
Observations	4880	9760
Adjusted R^2	0.475	0.459
Company fixed effects	Y	Y
Year fixed effects	Y	Y

Note: t-values are reported in parentheses, and *, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

As shown in Table 3, the regression analysis of experimental group indicates that the coefficients for the market risk premium (Rm-Rf), small minus big factor (SMB), high minus low factor (HML), and emissions trading price factor (natural log of carbon emission trading price) are 98.442, 39.565, 67.638, and -0.338 respectively.

1) Rm-Rf: The coefficient of 98.442 indicates a strong positive relationship between the market risk premium and the stock returns of high carbon-emitting companies. This indicates that as the risk premium in the market increases, the returns on these high carbon-emitting stocks also increase, suggesting these stocks are considered riskier assets.

2) SMB: This factor also exhibits a positive relationship with the stock returns as indicated by a coefficient of 39.565. This shows that larger companies (in terms of market capitalization) tend to have higher stock returns. This might suggest that larger companies, particularly those with high carbon emissions, often have more robust financial structures enabling them to digest environmental risks and uncertainties better.

3) HML: The positive coefficient of 67.638 indicates a positive relationship between the book-to-market ratio and the stock returns. Companies with a high book-to-market ratio can indicate intrinsic value which might be recognized by the market over a period of time, resulting in higher stock returns.

4) Carbon Trading Price factor: The negative coefficient of -0.338 for the Carbon Trading Price actor indicates an inverse relationship between the carbon trading price and the stock returns of high carbon-emitting companies. This finding may reflect the investment market's attention to environmental issues, the punishment imposed on high carbon-emitting companies, and the adverse impact of environmental governance costs on their profitability. The mentioned punitive mechanisms and adverse effects offset and exceed the market risk premium associated with the transition of such companies towards a low-carbon trajectory, thereby leading to lower returns.

The calculated t-values for these variables show that the market risk premium, book-to-market factor and the carbon trade price factor are statistically significant predictors (using a 90% confidence interval as a standard, t-value >1.645). However, the size factor is not statistically significant, indicating that its influence on the stock returns of high carbon-emitting companies is not statistically reliable.

Please note that this analysis is based on the provided coefficients and does not take into account other important considerations such as the state of the economy or specific industry trends which might also have an impact on these relationships.

The regression results of the control group indicate that although the coefficient of carbon trading prices remains negative, suggesting a negative effect on stock returns, it also sheds light on the green finance attributes of the carbon emissions trading market. However, this variable, carbon trading prices, is statistically unreliable and does not exhibit significant influence on the overall stock market.

5. Conclusion

This study aims to assess the environmental governance effectiveness of China's carbon market and the impact of carbon prices on stock returns. The empirical findings suggest that China's carbon emissions trading market has a positive impact on the country's green development. The decrease in demand for emission rights and the increase in supply have led to a downward trend in carbon trading prices. This is attributed to China's efforts in promoting industrial and energy structure adjustments, as well as the acceleration of carbon emissions reduction through green technological innovation by Chinese companies.

In reality, high-emitting companies are exposed to carbon risks as they may face higher carbon prices due to future global climate crises. Therefore, some scholars argue that there exists a carbon premium in related stock returns. However, the empirical results support the conclusion that high-emitting companies are negatively affected by carbon trading prices, resulting in lower stock returns. This indicates that the impact of carbon trading prices on the costs and investor confidence of high-emitting companies is more significant compared to the carbon risk premium. However, the experimental results of the control group indicate that the conclusion above does not apply to all industries.

In general, when viewed through the lens of green finance, the impact of China’s emissions trading market manifests positively. This market, a policy instrument predicated on market strategies for the reduction of emissions, effectively directs corporations towards the reduction of their carbon emissions. Nonetheless, the success and efficiency of the carbon market are contingent upon the progression and refinement of certain supporting conditions. Primarily, the extent to which marketization is integrated into the entire emissions trading system directly influences the efficiency and efficacy of the carbon market. Market operations, in principle, have the potential to establish equilibrium carbon price signals. However, given the disparity in the developmental stages of each pilot project and the sway of local trade policy, suitable direct policy intervention is indispensable. Secondly, the establishment and practical operation of the carbon market are reliant on rigorous laws and regulations. Compared to globally mature carbon trading systems, the legal infrastructure pertaining to China’s carbon market is notably deficient. The legal framework and mechanisms within the carbon market system are intrinsically interdependent. Further, the fortification of the relationship between China’s carbon market and the global counterpart could lead to significant economic and political advantages.

References

[1] Luo, J., & Xu, Z. (2019). Research on the Relationship among Investor Sentiment, Crowded-trade Behavior and Stock Risk Premium. Price Theory and Practice, 2019 (10), 83-86.

[2] Zhang, Y., & Zhu, H. (2017). Influencing factors of stock market risk premium based on BJS method. Science and Technology Management, 19(02), 63-67.

[3] Lin, J., Chen, L., & Tian, L. (2021). Is Monetary Policy Uncertainty a Pricing Factor for China's Stock Market? Quarterly Journal of Economics, 21(04), 1275-1300.

[4] Xu, Y., Qiu, Z., & Wang, H. (2019). The Effects of Macroeconomic Conditions on Asset Pricing Factors. Economic Theory and Economic Management, 2019(09), 45-58.

[5] Chen, G., Guo, J., & Zhao, X. (2021). Research Progress on Climate Finance. Journal of Economic Dynamics, 2021(08), 131-145.

[6] Castro, P., Gutiérrez-López, C., Tascón, M. T., & Castaño, F. J. (2021). The impact of environmental performance on stock prices in the green and innovative context. Journal of Cleaner Production, 320, 128868.

[7] Tiwari, A. K., Aikins Abakah, E. J., Gabauer, D., & Dwumfour, R. A. (2022). Dynamic spillover effects among green bond, renewable energy stocks and carbon markets during COVID-19 pandemic: Implications for hedging and investment strategies. Global Finance Journal, 51, 100692.

[8] Pedersen, L. H., Fitzgibbons, S., & Pomorski, L. (2021). Responsible investing: The ESG-efficient frontier. Journal of Financial Economics, 142(2), 572-597.

[9] Pan, C., Sun, T., Mirza, N., & Huang, Y. (2022). The pricing of low emission transitions: Evidence from stock returns of natural resource firms in the GCC. Resources Policy, 79, 102986.

[10] Bouri, E., Iqbal, N., & Klein, T. (2022). Climate policy uncertainty and the price dynamics of green and brown energy stocks. Finance Research Letters, 47, 102740.

[11] Wen F., Wu N., Gong X. (2020). China's carbon emissions trading and stock returns. Energy Economics, 86, 104627.

[12] Wang W., Zhang Y.-J. (2022). Does China's carbon emissions trading scheme affect the market power of high-carbon enterprises. Energy Economics, 108, 105906.

[13] Jiao, W., & Lilti, J.-J. (2017). Whether profitability and investment factors have additional explanatory power comparing with Fama-French Three-Factor Model: Empirical evidence on Chinese A-share stock market. China Finance and Economic Review, 5(1), Art. no. 7.

[14] Fang, T., Su, Z., & Yin, L. (2021). Does the green inspiration effect matter for stock returns? Evidence from the Chinese stock market. Empirical Economics, 60(5), 2155-2176.