

Climate Change Effects in Stock Markets

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Abstract. Climate change significantly impacts global stock markets through both short-term extreme weather events and long-term climate shifts. This study examines the relationship between CO₂ emissions and stock returns across 19 countries from 2001 to 2020 using regression analysis. The findings also reveal a positive correlation between CO₂ emissions and stock returns, indicating that investors anticipate higher returns to offset climate-related risks. This suggests that higher CO₂ emissions drive investor expectations for increased returns to compensate for potential economic losses. The study highlights the importance of balanced emission reduction strategies and promoting green finance to support sustainable economic growth. Additionally, it underscores the need to integrate climate risks into financial decision-making, offering valuable insights into the financial implications of climate change and guiding policymakers and investors in addressing these challenges. By providing empirical evidence on the link between CO₂ emissions and stock returns, this research enriches existing knowledge and emphasizes the financial risks and opportunities presented by climate change. The study's results align with the carbon risk premium theory, which posits that investors demand higher returns from companies with higher carbon emissions. This study advocates for policies that balance economic growth with environmental sustainability, promoting green finance initiatives to facilitate the transition to a low-carbon economy and mitigate the adverse effects of climate change on financial markets.

Keywords: Global; Climate change; Stock return; Regression analysis.

1. Introduction

Climate change is a major global challenge with severe impacts on human survival and socio-economic development, drawing widespread attention from the international community. According to the 2021 Scientific Assessment Report on Climate Change by the United Nations Intergovernmental Panel on Climate Change, global temperatures have risen dramatically since the 1970s, and the period from 2016-2020 is the hottest five-year period on record [1]. Climate change has increased the frequency and intensity of extreme weather events such as heat waves, droughts, and tropical storms, severely affecting agricultural production, people's lives, and economies. Therefore, addressing climate change has become an urgent problem for all countries.

Considering that extreme weather significantly impacts the production and operations of enterprises, leading to profit loss and cash flow shortages, it further increases the risk of the stock market. This paper enriches relevant research by analyzing the impact mechanisms across 19 countries, providing useful suggestions for stockholders. Quantifying the impact of climate change on the stock market helps regulators conduct targeted financial supervision, thereby minimizing risks faced by market participants.

The effects of climate change can be grouped into three categories:

(1) Short-term climate change effects: Increasing severity and frequency of extreme weather events (e.g., hurricanes, tsunamis, high temperatures) resulting in economic costs and financial losses [2].

(2) Long-term climate change effects: Gradual changes in climate (e.g., precipitation changes, average temperature rise) leading to the decline or loss of asset values [3].

(3) Transitional impacts: Systemic shifts during the transition to a low-carbon economy to achieve "net zero" emissions, potentially affecting financial system stability through asset revaluation, debt defaults, and the formation of bubbles in rising industries [4].

Based on the above findings, due to differences in research methods and data, as well as differences in policy effects caused by climate change, existing studies on the mechanism of action and interaction of carbon emissions on stock market returns are relatively scattered and lack of systematization. Therefore, this paper will systematically focus on the impact of long-term climate impacts caused by temperature changes on the stock market.

Climate change results from a series of complex environmental factors. Carbon dioxide emissions, a major atmospheric pollutant which are considered an important indicator reflecting climate change and environmental effects. CO₂ emissions have been increasing rapidly since 1960 [5]. At the same time global warming is primarily caused by human emissions of greenhouse gases, and CO₂ emissions are the main source of GHG from human activities [6]. Therefore, using CO₂ as an important indicator to measure climate change allows for the effective study of its impact across different fields.

2. Literature review

This study enriches the existing body of knowledge with empirical evidence on the effects of CO₂ emissions on stock market returns across countries. By highlighting the correlation between CO₂ emissions and stock returns, the study aims to highlight the financial risks and opportunities posed by climate change

2.1. Related research

Changes in investor decisions caused by the increase in CO₂ emissions are an important channel affecting stock returns. Therefore, the effect of CO₂ concentration on investor decision-making and sentiment will be briefly analyzed in the following paragraphs.

As CO₂ concentrations increase, investors will find the air more unacceptable and unpleasant, and this negative perception will affect their mood and decision-making process. High levels of CO₂ also have a negative impact on investors' cognitive performance, with studies showing that at 3,000 ppm CO₂ concentration, attention is reduced, making it more difficult for investors to make complex decisions or process large amounts of information in high CO₂ environments [7]. At the same time, high concentration of CO₂ may increase the psychological pressure of investors, further affect their decision-making ability, make them more susceptible to market fluctuations and negative news and will make emotional investment decisions, but also this will help investors to be more cautious when making investments.

Meanwhile, as an important direction in this field, carbon risk premium refers to the additional financial return due to the risks caused by carbon emissions of enterprises. In the early days of the EU ETS, companies that received free carbon credits gained increased cash flow, making them more financially advantageous [8]. In addition, the formation of carbon risk premium is also closely related to the carbon emissions of enterprises. Studies have shown that companies with higher carbon emissions have higher expected stock returns due to higher exposure to carbon risks [9]. This finding suggests that carbon risk not only affects the financial performance of companies, but also creates a significant risk premium in the stock market.

2.2. Composition of article

The following structure of this paper is as follows: The second part describes the data sources and research methods; In the third part, the relationship between emission reduction commitment and carbon risk premium is analyzed in detail and verified by empirical results. The fourth part discusses the influence of different firms and environmental factors on this relationship. The last part summarizes the research findings and puts forward policy recommendations and future research directions.

3. Methods

Based on a global perspective, this paper explores the impact of CO₂ emissions on stock returns through regression analysis by collecting panel data from 19 countries during 2001-2020.

3.1. Data source

Data sources used in this article include World Bank databases, EIA websites, and Yahoo Finance. The weighted average method was used to fill in some missing data. Table 1 details the definitions and data sources for the above variables.

Table 1. Variable definitions and data sources

Variable name	Definition	Unit	Source
Year	Yearly data	Number	/
E(R)	Annualized stock return	Percentage change	Yahoo finance
CPI	Consumer price index	Score	World bank
CO ₂	Carbon dioxide emissions	Gross kiloton	EIA websites
GDP	Gross domestic product	Million dollars	World bank

3.2. Model design

For the samples collected in this paper, R studio was used to conduct regression analysis on the correlation between CO₂ emissions and annual stock returns (including gross domestic product (GDP) and consumer price index (CPI)) to test the stability of experimental results. In this paper, the panel data regression method is used for analysis, and the model can be matched with the data, and the results are unique to the degree of correlation between each factor. However, the limitation of regression analysis is that some important information may be lost.

Based on the above considerations, the regression measurement model is established as follows:

$$E(R_{i,t}) = \beta_0 + \beta_1 * CO_{2i,t} + \beta_2 * GDP_{i,t} + \beta_3 * CPI_{i,t} + \varepsilon \quad (1)$$

In Formula 1, $E(R_{i,t})$ represents annualized stock return; The value of i ranges from 1 to N , and the value of t ranges from 1 to T . β_0 is a constant term; β_1 is the coefficient of the independent variable; $CO_{2i,t}$ represents the total CO₂ emissions of Country i in year t ; β_2 is the coefficient of GDP; GDP represents the total GDP of the country i in year t ; β_3 is the coefficient of CPI; which represents the CPI score of the country i in year t ; ε is the error term

3.3. Statistical result

This paper intends to use the panel data of 19 countries from 2001 to 2020 to conduct an empirical study on the global stock market and reveal the volatility direction of the stock market in the context of climate change.

After explaining the indicators and data sources, this part describes the variables adopted, and the basic distribution is shown in Table 2.

Table 2. Descriptive statistics of variables

Variables	N	Mean value	Standard deviation	Maximum value	Minimum value
E(R)	380	0.05198274	0.228876	1.304334	-0.653941
CO ₂	380	1147472	2077941	10944686	30290.6
GDP	380	2521592	3847793	21521400	53872
CPI	380	1.8	1.762498	11.98939	- 1.352837

As can be seen from Table 2, each variable has a good observable value. The standard deviation of stock return rate is 0.228876, indicating that the stock return rate of the sample countries fluctuates greatly, reflecting the influence of exogenous variables such as economic, policy and environmental factors. This indicates that the CO₂ emission index variables of climate change are relatively obvious,

with an average value of 1147472 and a standard deviation of 2077941, indicating that there are great differences among different countries.

From the perspective of other explanatory variables, the standard deviation of variable GDP is 3847793, reflecting the large macroeconomic differences among the sample countries, which need to be considered in the subsequent analysis. Similarly, the standard deviation of the variable CPI is 1.762498, reflecting the high volatility of price levels in the sample countries. These fluctuations can be influenced by a variety of factors, including economic policy, supply and demand.

3.4. Regression analysis

Through the regression analysis of climate change and stock return model considering the year effect, the regression results can be obtained (Table 3). Table 3 provides dynamic panel regression estimates for all plate samples.

Table 3. Results of model regression estimation

Symbol	(1)
CO2	1.662e-08 (1.935)
GDP	-4.389e-09 (-0.959)
CPI	-1.750e-02 * (-2.575)
year	fixed
R ²	0.01574
F	3.021

The increase of CO₂ emissions increases stock returns. In all regression results, the coefficient of CO₂ is 1.662e-08, showing statistical significance. Specifically, when other control variables remain unchanged, for every 1 kt increase in total CO₂ emission, stock return will increase by 1.662e-08 units. This empirical result is consistent with Bolton and Kacperczyk's [10] research conclusion on the relationship between climate change and stock market.

According to the results in Table 3, the increase of GDP and CPI has a negative impact on stock returns. Specifically, CPI coefficients are significantly negative, and the rise of CPI means the increase of inflation, indicating that the rise of inflation may have a negative impact on the stock market. High inflation is often associated with higher interest rates and uncertainty, which can dampen stock return. Moreover, GDP is also negative, which means that if GDP increase by 1million, stock return rate will decrease by 4.389e-09, which indicates that GDP has a negative impact on stock return rate.

3.5. Stability analysis of carbon emission on stock returns

Both political and economic events can have a significant impact on climate change and stock returns. Since 19 years of panel data are used in this paper, the structural breakpoint effects that occur during this period need to be considered. Structural breakpoint is a common phenomenon in economic research, and it is also an important problem in macroeconomic analysis.

Stock returns have always been in dynamic changes, it is difficult to accurately describe its dynamic characteristics, and it is difficult to effectively prevent such widespread and extensive external factors as the global financial crisis in 2008. Therefore, "Panel (B)" is constructed after the model will exclude the 2008 observation data. By comparing the results of different empirical regression analyses of Panel (A) and Panel (B), the robustness of the above research conclusions is tested. The specific regression results are shown in Table 4.

Table 4. Stability test (2008 financial crisis)

Symbol	(2)
CO2	1.436e-08 (1.827)
GDP	-3.744e-15 (-0.895)
CPI	-3.505e-05 (-0.005)
year	fixed
R ²	0.002835
F	1.341

It can be seen from Table 4 that, considering different time periods, climate change can promote the improvement of stock returns, and the emergence of financial crisis has an important impact on the impact of climate change on stock returns.

According to the regression results of Panel B, after excluding the impact of the 2008 financial crisis, variables CO2 still have a significant positive impact. It is indicated that, excluding the influence of financial crisis, all sample countries should change the climate and promote the increase of stock returns. Compared with the original panel, the CO 2 regression coefficient of panel B is relatively small, indicating that under the assumption of panel B, the impact of climate change on stock returns is not so significant, which means that although climate change has a certain effect on improving stock returns, the 2008 financial crisis has weakened this impact to some extent.

4. Discussions

Climate factors are increasingly being considered in investment decisions. First, the sustainability sector is rising with increased environmental awareness and the climate change agenda, which will bring more investment opportunities. Second, investors should actively participate in and support the development of sustainable finance, such as investing in sustainable bonds and environmental protection funds, to drive the economic transition to sustainable development, while reaping both financial and environmental returns.

To address climate change, it is most important to properly handle the relationship between energy conservation and emission reduction and economic growth. The first is to reduce greenhouse gas emissions, while ensuring continued rapid economic growth. This requirement echoes the inevitable requirements of economic development and against climate change, in which market mechanisms will play an important role. For example, through carbon markets, companies can be guided to reduce carbon emissions and reduce their dependence on energy. At the same time, emissions trading provides financial institutions with a source of investment and income.

Climate change risk is becoming an important consideration for institutional investors in their investment decisions [11]. Therefore, future studies can further explore how to better play the positive role of climate change and minimize the huge losses caused by climate change risks to the stock market and the economy and society.

5. Summary

In summary, the increasing risks of climate change have caused huge losses to countries. The results of this study show that climate change has a positive effect on stock market returns, which is consistent with the traditional "carbon risk premium" theory, which investors expect higher returns on securities issued by carbon-emitting companies to compensate for their exposure to climate policies.

Climate change has a driving and enhancing effect on stock returns. Through linear regression analysis, it can be found that the increase in CO₂ emissions is positively correlated with the increase in stock returns. This is because the losses caused by climate change further increase people's expectations of risks and worries, thereby driving people to pursue higher stock returns to compensate for the economic losses that may be caused by climate risks.

After considering the impact of different macro factors, the impact of climate change on stock returns is still significant, indicating that the country's economic development level plays an important role in the impact of climate change on stock returns. This shows that when the economic growth rate is fast, people have strong confidence in the economy and the stock market. When the risk of climate change increases, people will spend more disposable income on consumption and investment, thereby increasing the return rate of stocks.

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