Construction of a climate risk index under the media attention perspective and its empirical test for financial market volatility

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Abstract: Under the current economic situation, China's economy is steadily moving from the stage of high-speed growth to that of high-quality development. while climate risks arising from global warming are receiving increasing media attention. Media attention has a profound impact on the perception and investment decisions of financial market participants. This paper constructs a climate risk index based on media attention and empirically investigates its relationship with stock volatility. It is found that the climate risk media index significantly affects stock volatility, which provides a theoretical basis for the regulation of financial asset price volatility. Through in-depth study of its influence mechanism, it can provide accurate decision support and risk management strategies for financial market stabilization.

1.Introduction

In today's age of accelerated globalization and information, the media plays an important and influential role in connecting people around the world. Climate change has become one of the most significant challenges facing humankind, and extreme climate change caused by global warming will have irreversible and catastrophic effects on the Earth's ecosystem. Extreme weather events caused by global warming disrupt the growth of crops and affect the global food supply [1].In addition, climate change affects a number of industries, including energy and transportation, increasing operating costs and reducing economic efficiency[10]. Uncertainties associated with the green transition may also affect the stability and development of economic and financial systems. These economic losses not only affect the lives of individuals, but also pose a serious threat to economic stability and development. Therefore, addressing climate risks and reducing economic losses has become a common global challenge. Although the probability of climate disasters is small, when they occur they will cause serious losses to the economy.

With the frequent occurrence of climate-related events, the media's coverage of and attention to climate risk has shown a trend of gradual increase. In recent years, with the booming development of the Internet, online media has become one of the main carriers of information dissemination. This study aims to explore the impact of media attention to climate risk on financial markets. It not only helps to deepen our understanding of the mechanism of climate change impacts on financial markets, but also provides an important reference for the development of financial policies and investment strategies to address climate risks in order to cope with the increasingly severe climate challenges.

In the past, relevant studies[23] have demonstrated the existence of the volatility effect of online media attention on the stock market. The information disseminated by online media affects the way investors make decisions. When media attention is too high or too low, it can trigger volatility in the stock market[45].From the perspective of climate risk, on the one hand, when climate risk occurs, unfavorable climate shocks may lead to a fall in the price of financial assets. The occurrence of climate risk triggers a rise in financial market volatility, and the two are positively correlated. On the other hand, however, uncertainty in economic activity is itself an important driver of climate change uncertainty, i.e., rapid economic growth may lead to increased greenhouse gas emissions, exacerbate climate change, and increase climate risk, thereby undermining economic growth. Thus, current economic growth may negatively affect future economic growth through climate feedback mechanisms[6].

The above studies illustrate that media and climate risk both have an impact on the stock market, however, it is often the case that media and climate risk are considered in isolation from each other. Therefore, this paper refers to the methodology of Robert F Engle[9] et al. to combine the two and construct a media index of climate risk based on media attention to study its impact on financial markets. Among them, since stock volatility, as an important indicator of financial market volatility, can directly reflect the magnitude and frequency of stock price changes. Since stock volatility, as an important indicator of financial market volatility, can directly reflect the magnitude and frequency of stock price changes, and stock volatility is

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used as a proxy variable for financial market volatility in most of the academic research on financial markets, this paper also uses stock volatility as a proxy variable for financial market volatility. In addition, considering that each province has different economic development and climate conditions due to geographic location differences, we refine the granularity to provinces and study them. In summary, the analysis shows that the term structure of climate risk premium may be upward or downward sloping due to climate policies and other factors. Accordingly, the following hypothesis is proposed:

Other things being equal, the climate risk media index is positively correlated with stock volatility.

2.Research design

2.1 Sample Selection and Data Sources

The research time span of this paper is set from July 2, 2018 to July 31, 2023, and the time is chosen to ensure the timeliness and completeness of the data in order to more accurately reflect the impact of media attention on the climate risk index. In terms of media selection, we uphold the principles of content authenticity and authority, and the selected media are all paper media with electronic versions. These media not only have wide dissemination and influence, but also their report contents have been strictly reviewed and screened, with high credibility and reference value. At the national level, we carefully selected eleven comprehensive newspapers as our research sample. These newspapers have more original content and less reprinted content, ensuring the independence and originality of the study. At the same time, they support time skipping and data crawling, which facilitates our access to detailed and reliable data. In the selection of local media, we followed a similar principle, and each province or municipality directly under the central government chose a representative local newspaper, usually a local daily newspaper. These newspapers reflect the characteristics and development of each region, which provides us with a strong support for an in-depth study of media attention in different regions. It is worth noting that in selecting local media, we have fully considered the local economic development and the actual paper situation. For example, in Guangdong Province, an economically developed province, we chose two newspapers, Guangzhou Daily and Shenzhen Special Zone Daily, for the comprehensive calculation to reflect the media attention of the region more comprehensively. However, newspaper websites in a few provinces have strict anti-crawler reconnaissance mechanisms, such as Heilongjiang and Gansu, which prevented us from obtaining the required data from these websites.

For financial stocks, we have selected the CSI 300 constituent stocks as representative of the national financial stocks. These stocks cover a wide range of industries and sectors with high market representation and influence. For local stocks, we selected companies from various provinces from the Cathay Pacific database as our research sample. The stock price fluctuations of these companies can reflect the development of the local economy and investor confidence. In the end, we succeeded in obtaining 28 data including the whole country. In terms of data sources, the CSI 300 stock data comes from the Wind database, and the local stock data with the original data of control variables comes from the CSMAR Cathay Pacific database. The media data, on the other hand, comes from the electronic version of each newspaper. In summary, this study follows strict academic norms and research methods in media selection, financial stock selection and data analysis to ensure the accuracy and reliability of the study.

2.2 Definition and description of main variables

The main variables used in this paper are the media index and stock volatility, as defined below.

2.2.1 Explained Variables

The explanatory variable in this paper is set as stock volatility (Vol), an indicator chosen to reflect the volatility of stock prices in the financial market. Given the rapidly changing nature of financial markets[78], stock prices are updated in real time and it is particularly important to accurately capture their volatility status. Therefore, we use a calculation method based on the daily closing price to measure the stock volatility of a firm. After calculating the stock volatility of each firm, in order to synthesize the volatility of the overall financial market in a province, we aggregate the stock volatility of all firms within that province. In this process, we adopt a synthesis method that uses the total corporate assets of each company as the weight. This way of setting weights can fully consider the influence of enterprises of different sizes in the financial market, making the synthesized financial index more representative and accurate. Finally, we get the stock volatility of a province, i.e. the financial index of the province. The specific calculation formula is as follows:

$$R_{m,i,t} = \ln P_{m,i,t} - \ln P_{m,i,t-1} \tag{1}$$

$$\sigma_i = \sqrt{\frac{\Sigma_{j=1}^{n}(R_{i,t} - \overline{R})^2}{n-1}} * \frac{S_{m,i}}{\Sigma_{i=1}^{k} S_{m,i}} \tag{2}$$

In the formula, $P_{m,i,t}$ denotes the closing price of stock i in province m at moment t; $R_{m,i,t}$ denotes the logarithmic return of the difference between the stock price of stock i in province m at moment t and at moment t-1; $\overline{R}$ denotes the average return on stock i over a specified period of time; σ_i denotes the standard deviation of stock i's return over the cycle; n denotes the number of trading days in the cycle. $S_{m,i}$ is the total corporate assets of firm i in province m, and k is the total number of firms in province m.

2.2.2 Explanatory variables

The explanatory variable in this paper is the media index (Med). When climate risk occurs, the relevant media will

react quickly and report on the risk. After acquiring the information transmitted by these media, investors will make corresponding investment decisions based on their own judgment and analysis, which in turn affects the stock price of enterprises[11]. Therefore, the media index, as an explanatory variable, can effectively reflect the degree of media attention to climate risk events, which can then be used to analyze how this attention affects investors' decisions and the market performance of enterprises.

When calculating the media index, the following steps were performed to ensure the accuracy and reliability of the results:

Step 1 Construct a corpus.

We collected sixteen climate white papers from twelve Western countries or international organizations, including the EU, which provided us with relatively more in-depth analyses and comprehensive descriptions of climate risk research in the West. Subsequently, we utilized Python technology to perform keyword crawling on these white papers, and filtered out the top 480 words with the highest frequency of occurrence by removing commonly used words and integrating synonyms as keywords in the white paper section.

At the same time, we also captured climate-related news reports from thirty-five Chinese news media in the past year. As domestic mainstream media, these news media have wide dissemination and influence, and their reports can reflect the domestic concern and attitude towards climate risk events. Through the same process, we screened out the top 500 words with the highest frequency of occurrence as the keywords of one year's climate news.

After obtaining the two groups of words, we compared and integrated them. By comparing the commonalities and differences between the two groups of words, we finally left 50 words, which appeared in both the white paper and the keywords of one year's climate news, and which are both representative and able to comprehensively reflect the characteristics and connotations of climate risk events. These 50 words constitute our climate risk keyword corpus, which provides a solid foundation for subsequent computation and analysis.

By constructing the corpus and screening the keywords, we provide effective data support for calculating the media index. Next, we will use these keywords to quantitatively analyze the media coverage in order to derive specific values for the media index. This process will allow us to examine in greater depth the relationship between media attention and climate risk events and how this relationship affects the performance of financial markets. The corpus results are shown in Table 1.

Table 1: Corpus

health	forest	temp	grain	green
natural	ocean	forest fire	rainfall	flood
fall	carbon	plant	energy	warm
conservatory	situation	ecology	exposure	agriculture
magnanimity	strategic	preservation	environment	drought
sea level	Drought resistant	wildfire	condition	biotechnology
protect	heat	CO_2	glaciers	fire
resource	hurrican e	emission	eco-friendly	reduce disaster
extreme	hydrologic	responsive	rainstorm	turmoil

Step 2 Capture the news and calculate the BM25 value

To ensure the timeliness and comprehensiveness of the study, we set a time span in weeks and collected all news reports from July 2018 to July 2023 from eleven mainstream media outlets nationwide as well as a total of twenty-seven newspapers in various regions. These news data not only cover information from different geographic regions, but also reflect the perspectives and attitudes of different media outlets in their coverage of climate risk events.

A uniform standard and approach was used in the processing of the news data. Specifically, the weekly news reports of eleven national media were consolidated into a single document. For provincial newspapers, on the other hand, we divided them by province, and the weekly news for each province was also consolidated into a single document, which helped us to gain insight into the differences in media attention and coverage in each region.

For keyword extraction, instead of using the traditional TF-IDF method, we chose the more advanced BM25 algorithm.BM25 algorithm has a good performance in text retrieval and keyword extraction, which is capable of calculating the weight of a word according to the factors such as word frequency, document length and the distribution of the word in the document, so as to reflect more accurately the criticality of the word in the document.

Using the BM25 algorithm, we calculated the BM25 value for each vocabulary word in each document. This value represents how critical the vocabulary is in this week's document. By comparing the BM25 values of different vocabularies, we can clearly see which vocabularies are more critical in this week's news story.

Overall, through news crawling and the calculation of BM25 values, we successfully extracted the key information in the news reports, which provided strong data support for the subsequent analysis of the impact of media attention on the climate risk index.

Step 3 Calculate the media index

Each document was left with the words with the top fifty BM25 values as the keywords for that week's document, which were compared with the words in the corpus and assigned values for the calculation. The specific assignment method is as follows: if the word in the weekly document does not appear in the corpus, it indicates that the word has a low relevance to climate risk events, and therefore its position is recorded as 0; if the

word appears in the corpus, it is assigned a value based on the order of the BM25 value of the word in the weekly document. Specifically, words ranked in the top five BM25 values were assigned the highest weight of 1.0, words ranked sixth through tenth were assigned a weight of 0.9, and so on up to words ranked in the fiftieth position. In this way, we assigned a weight value to each keyword, forming a fifty-dimensional vector.

Finally, we calculate the cosine similarity between the obtained fifty dimensional vectors and the fifty dimensional vectors formed by the corpus, which are all 1. Cosine similarity is a commonly used text similarity measure, which can effectively measure the size of the angle between two vectors, thus reflecting the degree of similarity between texts. In this study, we use the calculated cosine similarity as the media index for that weekly document. This index not only represents the degree of media attention to climate risk events, but also can reflect the correlation between media reports and climate risk events.

The specific calculation formula is as follows:

$$A_i = (\omega_{i,1}, \omega_{i,2}, \omega_{i,3}, ..., \omega_{i,50}) \quad (3)$$

$$Med = \cos < A_i, B > \quad (4)$$

A_i denotes the vector formed by the assignment of the ith document. $\omega_{i,1}$ denotes the assignment of the 1st word of the ith document, and the latter term is the same. B is the vector of corpus composition.

2.2.3 Control variables

In order to ensure the validity of the research conclusions, this paper combines the individual characteristics of enterprises as well as draws on existing research, and selects the following indicators as control variables: enterprise size (Size), gearing ratio (Lev), net interest rate on total assets (ROA), and accounts receivable percentage (REC). Also fixed time and region. The definitions and descriptions of the variables are shown below in Table 2.

Table 2: Definitions and descriptions of variables

Variable Name	Variable	Variable Definition
Stock Volatility	Vol	Province or municipality directly under the central government stock volatility
Media Index	Med	Weekly climate news media attention
Enterprise size	Size	Natural logarithm of total assets
Gearing	LEV	Total liabilities/total assets
Net interest rate on total assets	ROA	Net profit/total assets
Accounts receivable as a percentage	REC	Accounts receivable/total assets

2.3 Modeling

As mentioned in the previous section, stock volatility is used as an explanatory variable, media index is used as an explanatory variable, and control variables are also added, and for the selected variables, some of them are logarithmized, and to test the hypotheses, the following model is constructed:

$$\ln Vol_{i,t} = \beta_0 + \beta_1 \ln Med_{i,t} + \beta_n Controls_{i,t} + \Sigma Year + \Sigma Area + \varepsilon_{i,t}$$

$Vol_{i,t}$ representing the stock volatility of region i in period t. β 0is the intercept term. β_1 is the coefficient on the core explanatory variable, the media index. $Med_{i,t}$ denotes the media index for region i in period t.$\sum$ Yearis year fixed. $\sum$ Area It's an industry fixture. $\varepsilon_{i,t}$ is a randomized perturbation term.If the regression coefficient β 1 is significantly positive, it indicates that media attention to climate risk has a significant effect on stock prices.

3.Results and Analyses

3.1 Descriptive statistics

The descriptive statistics of the variables are shown in Table 3. The mean value of stock volatility is 0.02 and the standard deviation is 0.006, indicating that there is not much difference in stock volatility across the sample regions, implying that despite the differences in geographic locations and market environments, investors may have similar behavioral patterns and risk preferences in different regions, resulting in a similar way of reacting to risk, which would make stock volatility vary little across regions.

The maximum value of Med is 2785.43 and the minimum value is 0, indicating that there is a more obvious gap between the occurrence of climate risk and media attention to climate risk in various regions, with the overall national average at 321.434. Some regions may suffer from frequent climate risk events and the media pays high attention to them; while in other regions, climate risk events may be rare and media attention is relatively low. For the control variables, the minimum

value of return on assets is negative, which implies the existence of provinces with negative net profits or whose profits are not sufficient to cover the cost of their assets during the data time period. This could be due to a number of factors such as changes in the market environment and errors in business strategies. Overall, there are no outliers.

Table 3 Descriptive statistical analysis of variables

Variables	Obs	Mean	SD	Min	Max
Vol	3871	.02	.006	.008	.041
Med	3872	321.434	666.362	0	2785.43
Size	3872	25.272	1.623	22.753	29.771
Lev	3872	.626	.112	.426	.932
Rec	3872	.059	.025	.009	.113
Roa	3872	.052	.135	-.023	.931

3.2 Correlation analysis

In this paper, intra-group correlation coefficient is used for correlation analysis. Table 4 shows the table of correlation coefficients, according to which it can be seen that the correlation coefficient between stock volatility and climate risk media index is 0.154 and significant at 1% level, which initially verifies the positive correlation between the two, and preliminarily concludes that the increase of climate risk media index will cause the fluctuation of stock prices. Among them, the correlation coefficients of all variables with stock volatility and climate risk media coefficient are less than 0.2, which basically exclude the interference of multicollinearity problem.

Table 4 Table of correlation coefficients

	lnvol	lnmed	size	lev	rec	roa
lnvol	1					
lnmed	0.154***	1				
size	-0.058***	-0.088**	1			
lev	-0.032**	-0.085**	0.835***	1		
rec	0.046***	0.105***	-0.572***	-0.514***	1	
roa	-0.005	-0.012	-0.331***	-0.362***	-0.093***	1

Note: ***, **, and * represent 1%, 5%, and 10% significance levels, respectively, as below.

3.3 Regression analysis

To verify that media attention to climate risk has an impact on stock price volatility, it is analyzed. The regression in this paper uses a time-area double fixed effects regression based on panel regression. The baseline regression is shown in Table 5, according to which the coefficient of the core explanatory variable climate risk media index is 0.0776 with a corresponding T-value of 2.595 when no control variables are added, and this variable has a significant positive effect on financial volatility at the 1% level. After adding the control variables, the coefficient of the core explanatory variable climate risk media index is 0.0784, the corresponding T-value is 2.625, and this variable has a significant positive effect on financial volatility at the 1% level. Therefore, the climate risk media index has a significant effect on financial volatility and for every 1% change in the media index, financial volatility changes by 0.0784% in the same direction. It indicates that the stronger the climate risk and the wider the scope of its impact, the media will pay more attention to climate risk, and investors who see the relevant reports will make risk assessment and then change their investment strategy, which will exacerbate the stock price volatility. Accordingly, the hypothesis is tested.

Table 5 Benchmark regression

	(1)	(2)
VARIABLES	lnvol	lnvol
lnmed	0.0776***	0.0784***
	(2.595)	(2.625)
size		0.0478
		(1.263)
lev		-0.273*
		(-1.810)
rec		0.720
		(0.781)
roa		0.420
		(1.648)
Constant	-4.564***	-5.680***
	(-20.27)	(-5.610)
Observations	769	769
R-squared	0.839	0.841

3.4 Robustness Tests

In this paper, the robustness of the benchmark regression results is tested by reducing the sample and the results are shown in Table 6. Considering the impact of the new crown epidemic, column (1) shows the regression results obtained by excluding the samples in 2020 and beyond, as can be seen, the coefficient of the core explanatory variable, the media index, is 0.191, corresponding to a t-value of 2.125, which shows that the variable still exhibits a significant positive impact on financial volatility at the 1% level, and the aforementioned study is still valid.

After excluding the nationwide sample data, the regression results in Column (2) are obtained, at this point, the coefficient of the core explanatory variable media index is 0.0794, corresponding to a T-value of 2.74, this variable still exhibits a significant positive impact on financial volatility at the 1% level, and the previous study still holds, indicating that the results of this paper are robust. The hypotheses are verified.

Table 6 Regression results after narrowing the sample

	(1)	(2)
VARIABLES	lnvol	lnvol
lnmed	0.191**	0.0794***
	(2.125)	(2.740)
size	0.0865	0.0392
	(0.449)	(1.065)
lev	-0.399	-0.286**
	(-0.221)	(-1.968)
rec	-1.518	0.668
	(-0.417)	(0.753)
roa	-0.137	0.406*
	(-0.0344)	(1.657)
		(2.086)
Constant	-7.221*	-5.457***
	(-1.797)	(-5.532)
Observations	156	738
R-squared	0.854	0.857

4.Conclusions

This paper experimentally concluded that there is a significant financial asset price volatility effect of climate risk media index, and it is significant at 1% level. Therefore, for investors and policy makers, we make the following recommendations:

For investors, they need to pay close attention to media reports and market sentiment, and should actively collect and analyze various types of information related to climate risk, so as to make reasonable assessments and forecasts of climate risk in a timely manner. In the investment decision-making process, investors should fully consider the impact of climate risk factors, review their investment portfolios on a regular basis to ensure that risks associated with climate change have been adequately considered, and conduct regular climate risk assessments. The most important thing is to remain calm and rational and make decisions based on comprehensive information. When dealing with financial assets related to climate risk, investors should also consider the impact of ongoing climate change and related policy changes.

For policymakers, climate risk management and information transparency can be promoted to reduce market instability. Relevant policies should be formulated and improved to encourage enterprises and financial institutions to strengthen climate risk management. At the same time, the development of climate-related financial products and markets should be promoted to provide investors with more diversified investment choices and improve market transparency and stability. In formulating relevant policies, the requirements of long-term development goals and climate sustainability should be fully considered and integrated, so as to promote the development of financial markets in a more sustainable and robust direction**.**

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