Carbon Neutrality

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Climate policy uncertainty and corporate investment: evidence from the Chinese energy industry

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Abstract

In recent years, with the increasing attention paid to climate risks, the changes in climate policies are also more full of uncertainties, which have brought tremendous impact to economic entities, including companies. Using the dynamic threshold model, this study investigates the nonlinear and the asymmetric effect of climate policy uncertainty on Chinese firm investment decisions with panel data of 128 Chinese energy-related companies from 2007 to 2019. The empirical findings indicate that the influence of climate policy uncertainty on firm investment is significantly nonlinear. Overall, climate policy uncertainty is not apparently related to corporate investments in the high-level range, while it negatively affects the investments in the low-level range. In addition, to be more specific, the negative impact of climate policy uncertainty on the mining industry is tremendous, while the influence on the production and supply of electricity, heat, gas, and water sector is remarkably positive. The results of this study could help the company managers and policymakers to arrange appropriate related strategies under different climate policy conditions.

Keywords: Dynamic threshold model, Climate policy uncertainty, Corporate investment

1 Introduction

Corporate investment is a fundamental and vital part of business activities for companies, which affects the company's input, product diversity, and business strategy. There is no denying that proper investment decisions are crucial to ensure sound commercial logic and sustainable growth in a company [1, 2]. However, corporate investment is so vulnerable to various factors. Research has indicated that outside factors, including oil price, economic policy, climate conditions, and inflation, become increasingly crucial to companies' investment decisions [3–6]. Climate policy aims to deal with the worsening climate conditions, but due to the constraints of practical needs, their implementation is very uncertain [7]. The economic activities of the companies will inevitably be impacted, especially in the energy industry, which is closely related to climate change or environmental protection [8]. As a result, it is crucial to explain the energy-related company's investment with climate policy uncertainty. In this paper, we study the relationship between investment in energy companies and climate policy uncertainty in the context of China, filling some gaps for this topic.

In the process of China's industrialization, with the rapid development of the economy, the environmental conditions of China have been destroyed, and it has become one of the largest carbon emitters around the world [9, 10]. In order to mitigate the resulting climate risks, China has also adopted a number of climate improvement policies. Among them, the construction of low-carbon cities is one of the most representative climate policies [11, 12]. Studies have shown that low-carbon cities do help companies to improve their carbon emissions [13]. However, as we all know, enterprises are still market participants whose main objective is to

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maximize benefits. The pressure of environmental improvement brought by climate policy may also affect the financial performance of the companies. The energy industry bears the brunt. On the one hand, as the current climate policy of low-carbon transition is increasingly strengthened, their original assets may face the risk of grounding, which directly results in their financial losses [14, 15]. On the other hand, the pressure of low carbon transformation leads to the change of social capital flow, which brings higher financing costs for these companies [13]. It would also bring about more technology research and development costs for energy industries [8].

The company's investment activities have always been the focus of attention of all stakeholders, and uncertainty from plenty of aspects can cause substantial interference to corporate investment. For example, the price of crude oil and other commodity fluctuations [16], the economic policy uncertainty [17]. In terms of other macroeconomic indicators, previous research has also shown a close linkage between changes in the macro market and company investment [18]. Some articles also examined the correlation between uncertainty and company-level or industry-level indicators, such as the uncertainty of product prices, industry uncertainty [19, 20], market uncertainty [21, 22] and the cash flow uncertainty [23, 24]. However, these researches are mainly focused on the connection between the commodity markets, stock and bond markets, and so on [25, 26].

Research on the relationship between the financial performance of companies and climate risk has gradually taken off. The seriousness of climate risks will make investors pay more attention to the environmental performance of enterprises, and climate news risk would be reflected in corporate bond yields [27]. Good corporate governance can improve the company's awareness of climate risk or carbon risk, which can lead to improved carbon performance [28]. It is worth noting that there is strong evidence that the impact of carbon risk on corporate investment is negative and statistically significant [29]. Studies have shown that carbon price shocks caused by climate risks can significantly affect corporate investment. Climate policies, such as carbon taxes, have a significant impact on corporate environmental spending and investment [30, 31].

Of course, various climate policies have also promoted the rise of "green investment" by companies, the most obvious being the prosperity of green bonds [32]. However, the impact of the climate policy uncertainty on company investment has not received enough attention. Furthermore, little literature focused on the effects of climate policy uncertainty on firm investment of Chinese companies considering the asymmetric effect, especially in the energy industry.

This paper combines the dynamic threshold model to examine the linkage between climate policy uncertainty and corporate investment. The threshold model refers to a model that considers asymmetric effects in the process of empirical analysis. This paper focuses on the energy industry and discusses the effect of climate policy uncertainty on firm investment of Chinese listed companies under different climate policy conditions.

Overall, this paper has these contributions: Firstly, this paper is the first to investigate the effect of climate policy uncertainty on energy-related firms' investment in China. Gavriilidis [7] pointed out that a potential area is examining the role of climate policy uncertainty on firm-level investment, especially for firms in climate-sensitive industries (for example, mining and energy), at the end of his paper about the construction of the climate policy uncertainty index. Little previous studies have discussed the linkage between climate policy uncertainty and firm investment and have not considered the asymmetric effects. This article fills this gap. Secondly, this study also highlights the fact that the asymmetric impacts and threshold points of climate policy uncertainty on firm investment are dissimilar in different sectors. Also, this article classifies the samples according to company characteristics and discusses the responses of corporate investment in various industries. The results of this study can help company managers and officials understand corporate investment better to make appropriate decisions under different climate policy conditions.

The rest of the paper is structured as follows: Section 2 reviews related literature. Section 3 introduces the variables and methods. Section 4 reports the empirical results, and Section 5 is the conclusions.

2 Literature review

From a financial point of view, investment is the process by which investors pay certain valuable assets because of the future income of the investee. The company's investment activities, in a narrow sense, is the act of taking the company property as input funds to obtain profits [33]. The essence of company investment is allocating funds rationally and realizing the enterprise's maximum value. Corporate investment is the core of company business activities [34]. It is easily affected by many factors, and many pieces of literature have discussed the impact mechanism of uncertainty on company investment.

Generally, uncertainty can affect corporate investment through multiple channels. Bernanke [35] first began to explore the effect mechanism between the uncertainty or irreversibility on the corporate investment at the theoretical level. When an investment project is irreversible, managers must choose the best time to invest in order to obtain the highest possible return based on the promised return and market information. Appelbaum and Katz [36] indicate that when companies are at a high level of risk aversion, they tend to reduce investment and production when faced with uncertainty. Moreover, because investment funds are irrevocable and companies need to avoid risks, company investment and uncertainty are significantly negatively correlated. Dixit and Pindyck [37] point out that when a company needs to make an unchangeable investment decision, the increase in uncertainty will reduce the company's investment level. Bhagat and Obreja [38] adopt a new cash flow uncertainty measurement method. They empirically find that cash flow uncertainty has a strong negative impact on the employment and investment of enterprises. Other uncertainties, such as those arising from trade conflicts, credit risk and fluctuations in energy prices, will bring about changes in corporate investment strategies [39–41].

In general, most scholars find and believe that uncertainty will adversely affect investment. However, corporate governance ability or behavior performance determines the specific results when facing uncertainty. For example, the evidence provided by Sanford and Yang [34] shows that the higher R&D investment of the company can significantly improve the investment responseability of the enterprise to the impact of external information uncertainty.

In the case of economic-related policy uncertainty, existing studies have found that the increase in this kind of uncertainty has a restraining effect on the economy and the real estate market, whether at the macro or micro level. This change also raises the financial cost of the market, and the company's investment will be reduced accordingly [42]. Julio and Yook [43] examined the effect of political uncertainty on company investment behaviour in 48 countries in a period from 1980 to 2005. The results show that the process of political activities directly reduces the company's investment decisions. Gulen and Ion [18] selected a news-based uncertainty index to measure policy uncertainty. Their findings indicate that for companies that are highly dependent on government expenditure, high economic policy volatility will have a more substantial negative impact on investment than companies less dependent on government expenditure. Kim and Kung [44] use significant economic and political events to represent economic uncertainty. After the uncertainty increases, the friction of asset reallocation will affect liquidation value, thus making the company be cautious about investment decisions under uncertainty.

China has excellent determination and action on environmental issues in recent years, various ecological policies have been closely implemented and achieved initial results. Although the core of climate policy is to mitigate climate change, it is actually inextricably linked with economic activities. Liu and Wang [8] found that the climate policy could significantly affect the short-term related behaviors and activities of energy-intensive industries. Energy companies will definitely have a greater impact and interference when facing climate policy uncertainty [45].

However, other scholars hold different views. Abel [46] suggests that if the company's ability to deal with uncertainty becomes more robust than before, risks could provide new opportunities and become investment incentives for decision-makers. In this circumstance, the linkage between company investment and uncertainty is positive. For companies that rely more on free funds in the market, investment is less affected by policy uncertainty. Ghosal and Loungani [47] used panel data from the US manufacturing industry to examine the effect of price uncertainty on firm investment. For all companies, the uncertainty does not affect the current investment. Phan et al. [48] established a data set covering 33,075 companies in 54 countries or regions. Based on these data, it can be concluded that large companies are more easily affected.

Xu et al. [49] empirically examine the correlation between total firm uncertainty and companies' capital expenditure in China. They find that higher uncertainty may increase corporate investment among government-controlled companies. They also suggest that government-controlled firms in financial distress are more likely to take a risk in a market full of uncertainty. In addition, with the popularity of corporate social responsibility, investors from all parties pay more attention to environment-friendly investment [50, 51]. For the traditional energy industry, if it can seize the opportunity of transformation to win the favour of investors, it will also help the long-term survival [52, 53]. Therefore, the pressure of climate policy may be turned into an impetus to increase investment.

To sum up, it seems certain that the company will be affected by the uncertainty. However, although most studies show that various uncertainties reduce corporate investment, in some cases, companies may increase their investment out of the idea of taking risks or because they are forced to do so. Based on the studies above, we put forward the hypothesis as follows:

H1: Climate policy uncertainty will significantly affect corporate investment for energy-related industries.

In addition to the uncertainty of climate, this paper also argues that GDP growth positively impacts company investment. Prior studies show that the overall economic development maintains its influence on the operating and development of domestic enterprises through taxation and government policies [18]. Moreover, in the process of China's economic reform, GDP is a vital achievement test standard, and the investment projects of energy companies usually have relatively large amounts. Furthermore, in China, companies in the energy industry are usually state-owned enterprises, and their business decisions are affected to a certain extent by the government and local officials [54]. As a result, the relationship between the investment expenditure of Chinese energy companies and GDP is involved, which has great research significance. It is more likely that a higher GDP growth rate positively influences firm investment expenditure.

To some extent, the growth of GDP also represents the strengthening of the country's economic strength, which often leads to more active financial market activities and more diversified investment and financing channels [55]. For example, with the further development and improvement of China's financial market, companies can complete investment and financing through various forms such as green bonds, even under the pressure of low-carbon transformation [56]. Therefore, the growth of GDP is likely to promote the investment activities of energy companies in most aspects. From the argument above, the second hypothesis is formulated:

H2: GDP growth positively impacts Chinese corporate investment in the energy industries.

Ghosal and Loungani [57] document that although the investment expenditure of all companies is negatively correlated with external fluctuations, different industries have different sensitivity to fluctuations. Specifically, the industry average of investment spending in sectors where companies are generally small is more sensitive to changes. In sectors with more large companies, the external uncertainty has a less negative impact on company investment. Some energy-related companies are energy suppliers in the market, while others are demanders. For example, according to the supply-demand relationship function in economics, the increase in oil prices is a good condition for the fossil energy supplier, which is beneficial to the company's business development and profitability. On the contrary, for the fossil energy demander, sharp fluctuations in oil prices are likely to lead to poor management of the company, and it is even impossible for the company to make a large-scale external investment in a turbulent market environment [58].

Even if they all belong to the energy industry and face the same risk impact, the company may have different investment strategies due to different technology intensity or the characteristics of the main business [59]. Grabinska et al. [45], through the analysis of Poland's energy industry, also found that differences in corporate internal governance structure and other characteristics will also lead to different corporate performances. Based on the previous literature that considers the impact of uncertainty on company investment by industry, the following hypothesis is formulated:

H3: The impact of climate policy uncertainty on company investment varies in different energy-related industries.

3 Data and methodology

3.1 Data and variables

To examine the effect of climate policy uncertainty on firm investment in Chinese energy-related industries, this study uses a balanced panel data of 128 Chinese energy-related companies' yearly financial statement data from 2007 to 2019. All financial data are taken from the Wind database. Since 2007, China's stock market regulatory authorities have regulated listed companies' accounting information disclosure standards. This makes corporate investment more standardized and comparable. So, our dataset period starts from 2007 and ends with the latest issued financial statements of the 2019 fiscal year. During this period, the data are relatively complete, making the sample more balanced. Besides, in order to eliminate the impact of listed companies operating in abnormal conditions, the data set also excludes "special treatment" (ST) shares. Also, this study winsorizes data to limit the effect of outliners. Specifically, observations outside the range of 1% and 99% are substituted with the observations lying on 1% and 99%. Based on the industry classification by CSRC,[1] this study considers the energy-related companies from two industries, the industry of production and supply of electricity, heat, gas, and water (Industry I), and the mining industry (Industry II).

This study applies the climate policy measurement of the previous study of Gavriilidis [7] to stand for climate policy uncertainty (*CPU*). His climate policy uncertainty index was calculated by refining climate-related policy changes in eight mainstream media. In these media reports, Gavriilidis [7] refers to the method of constructing economic policy uncertainty indicators of Baker [60] by retrieving reports that contain multiple keywords, such as "uncertainty" and "climate change" with "regulations", or "the White House". Then, combining the number of these reports with the number of all news and other factors, the climate policy uncertainty index is constructed.

Corporate investment (*INV*) in this study is measured by corporate investment expenditure divided by a company's total assets. We use indicators reflected firm

[1]China Securities Regulatory Commission(CSRC)

financial conditions and indicators related to economic environments to be control variables, including leverage (*Leverage*), Tobin's Q (*TQ*), company size growth rate (*Asset*), sales growth rate (*Sales*), Gross Domestic Product (*GDP*). The leverage ratio is a vital indicator account for investing and financing activities. Tobin's Q is used to indicate a firm's investment development chances [3]. Company size growth rate is widely agreed that corporate size is interrelated to the external environment and projects that the company can access, thereby further affecting the company investment expenditure [61]. The sales growth rate is the proxy of the company's internal financing capabilities and external investment capabilities [17]. The control variables also include real GDP growth in order to control for China's economic conditions, which may have an effect on firm external investment [62].

The specific definitions of our variables are shown in Table 1, and the descriptive statistics are displayed in Table 2.

3.2 Methods

3.2.1 Panel unit root test

Before the investigation, we need to test the data's stationarity first. Therefore, this study employs the IPS panel unit root test Im et al., [63] to examine the stationarity properties of the variables in this study. The IPS panel unit root test is as follow:

$$\Delta y_{it} = \rho_i y_{i,t-1} + \sum_{l=1}^{p_i} \phi_{i,l} \Delta y_{i,t-l} + \alpha_i d_{it} + \varepsilon_{it} \tag{1}$$

In this equation, $\rho_i = 0$ indicates that y has a unit root for individual I, while $\rho_i < 0$ implies that y is stationary. For heterogeneous coefficients, we need to consider the t_{ρ_i} to test the null hypothesis: $\rho_i = 0$ for all I, which is as follow:

$$t = \frac{1}{N}\sum_{i=1}^{N} t_{\rho_i}$$

where t is asymptotically N (0, 1) distributed.

Table 2 Descriptive statistics

Variables	Obs	Mean	SD	Min	Median	Max
INV	1664	0.07	0.05	0.0001619	0.0542005	0.2485481
CPU	1664	2.04	0.15	1.773317	2.023386	2.300853
Leverage	1664	0.57	0.26	0.065325	0.570164	2.25272
TQ	1664	1.66	2.39	0.1467915	0.9307284	17.0436
GDP	1664	0.08	0.02	0.061	0.078	0.142
Sale	1664	0.05	0.17	−0.6353185	0.0286031	0.8160951
Asset	1664	0.12	0.25	−0.346988	0.0709115	1.554026

This table shows the descriptive statistics of the variables of this study. "INV" is the interpreted variable, and "CPU" is the primary explanatory variable of our study. Additionally, other variables are the control variables to reduce the bias of our empirical models.

3.2.2 Regression model

Based on the literature about determinants of corporate investment behaviour Bond and Meghir [64], the baseline regression equation uses the lag of variable by one period, which is as follows:

$$INV_{i,t} = \beta_1 CPU_{i,t-1} + \beta_2 Leverage_{i,t-1} + \beta_3 TQ_{i,t-1} + \beta_4 \mathrm{GDP}_{i,t-1} + \beta_5 Sales_{i,t-1} + \beta_6 Asset_{i,t-1} + u_i + \varepsilon_{i,t}, \tag{2}$$

whereas u_i denotes the unobserved firm-specific effects and $\varepsilon_{i,\ t}$ is the error term.

To better examine the real relationship, we should take the nonlinearity and the possible asymmetry in the effect of climate policy uncertainty into account. To do this, the panel model with threshold effects [65] has been applied by some researchers to explore the asymmetric effects in corporate finance, such as the investment decision of firms under financial constraints. However, this model is static and assumes the covariates to be strongly exogenous, which can be restrictive in many real applications. Therefore, this study employs the dynamic model with threshold, referring to Wu et al. [66] and Diallo [67], allowing lagged dependent and endogenous independent variables. Then, the above model can be modified as follows:

Table 1 Variable definitions

Variables	Definition
INV	Corporate investment; calculated as capital expenditure scaled by total assets in a previous year
CPU	Climate policy uncertainty index; calculated by Gavriilidis [7]
Leverage	Calculated as total company debt/shareholder' s equity
TQ	Tobin's Q; calculated as market value scaled by total assets
GDP	Real GDP growth
Sales	Sales growth rate; calculated as the natural logarithm of sales in year t minus the natural logarithm of sales in year t-1
Asset	Asset growth rate; calculated as the natural logarithm of total firm assets in year t minus the natural logarithm of total firm assets in year t-1

This table shows the definition and calculation methods for all variables in this paper. "INV" is the interpreted variable, and "CPU" is the primary explanatory variable of our study. Additionally, other variables are the control variables to reduce the bias of our empirical models.

$$INV_{i,t} = \alpha + \alpha_1 INV_{i,t-1} + \alpha_2 CPU_{I\{CPU_{i,t-1} \le threshold\}} + \alpha_3 CPU_{I\{CPU_{I,T-1} > threshold\}} + \alpha_4 TQ_{i,t-1} + \alpha_5 GDP_{i,t-1} + \alpha_6 Sales_{i,t-1} + \alpha_7 Asset_{i,t-1} + u_i + \varepsilon_{i,t-1} \quad (3)$$

where $CPU_{i,\ t-1}$ is the threshold variable, $\boldsymbol{I}\{\cdot\}$ is an indicator function. The threshold variable in this paper is the lagged climate policy uncertainty. This threshold model describes the impact of climate policy uncertainty on investment in energy-related industries and the specific performance of the threshold when the degree of impact changes. In the process of running the threshold model, We set corporate finance-related variables as endogenous variables, leverage ratio, assets, etc. Climate policy uncertainty and GDP are exogenous variables. Additionally, the variables that lag by one period are used as the tool variables.

4 Results and discussion

In this section, we first test the data's stationarity by the IPS panel unit root test. Then, both the panel-data model and dynamic threshold model will be employed to examine the correlation and Influence transmission between climate policy uncertainty and company investment.

4.1 Panel unit root test and multicollinearity test

Before the regression analysis, the stationarity of the variables needs to be tested. Table 3 demonstrates the *p*-value and statistic of the IPS test, which indicate that all variables are stationarity. Based on these results, we can then employ the panel-data and dynamic threshold models to examine the linkage and influence transmission between climate policy uncertainty and company investment in Chinese energy-related companies. In addition, we performed a multicollinearity test on our variables based on the least square regression (OLS) through the variance inflation factor (VIF) test. Our test results show no significant multicollinearity among the variables in our model.

Table 3 IPS panel unit root test and variance inflation factor test

Variable	Statistic	p-value	VIF
INV	−9.2594	0.0000	
CPU	−2.3002	0.0107	1.0576
Leverage	−5.3371	0.0000	1.0898
TQ	−4.2299	0.0000	1.1417
GDP	17.4159	0.0000	1.1440
Sale	−11.9619	0.0000	1.0485
Asset	−12.4421	0.0000	1.0503

This table shows the unit root test results. When the value of P is less than 0.05, the unit root does not exist, and the panel sequence is stable. It can be seen that all the data series in this paper are stationary. From the test results of the VIF, there is no significant multicollinearity among the variables.

4.2 Regression analysis

Based on the outcomes of the panel unit root test and VIF values, the panel models are appropriate for examining the linkage and influence transmission between climate policy uncertainty and company investment. Following the literature involving companies in multiple industries [43, 68], we also examined whether the effect of climate policy fluctuations on the firm's financial decisions varies by industry.

4.2.1 Impacts of climate policy uncertainty

This part shows the results of the basic panel model. We analyze all companies in the data set and then divide them into two industries according to the Chinese industry classification standard, testing with the panel regression model, respectively. The dynamic threshold panel model will also be employed in the next part to further investigate the asymmetric effects of climate policy uncertainty on firm investment.

Table 4 demonstrates the empirical results of the dynamic panel estimation, which aims to explore the linkage and influence transmission between climate policy uncertainty and company investment in Chinese energy-related companies. Column 1 reports the overall outcome of policy uncertainty on firm investment. Columns 2 and 3 display the empirical results of the industry I and II, respectively. The results indicate that the negative effect of CPU on investment expenditure is statistically significant at 1% significance level overall and significant at 5% level for industry II. These results show that, on the whole, the increase of uncertainty of climate policy will lead to the decrease of investment expenditure of companies in China's energy-related industries. This shows our hypothesis *H1* overall. Judging from the results of different sub-industries, the negative impact of climate policy changes on the mining industry is much more significant. On the other hand, the effects on the industry I are not statistically significant. This proves the correctness of our hypothesis *H3*.

There are several possibilities that could make the mining industry more susceptible to disruption. China's coal mining industry occupies a leading position and is one of the main raw materials for power production. The use of mineral resources such as coal directly increases carbon emissions. Therefore, when climate policy changes, these traditional energy companies are the first to be hit. As mentioned earlier, mining companies may face large amounts of stranded assets (resources already mined or equipment used, etc.), leading to a

Table 4 Estimation results of the panel model

VARIABLES	(1) Overall	(2) Industry I	(3) Industry II
L.CPU	−0.0486***	− 0.0019	− 0.0423**
	(0.0173)	(0.0113)	(0.0195)
L.Leverage	−0.1072**	−0.0158	− 0.0987**
	(0.0480)	(0.0399)	(0.0474)
L.TQ	0.0002	−0.0076	0.0065*
	(0.0056)	(0.0050)	(0.0033)
L.GDP	0.2030***	0.3083**	0.0214
	(0.0493)	(0.1491)	(0.2898)
L.Sales	0.1047	−0.0050	0.0569***
	(0.0505)	(0.0535)	(0.0189)
L.Asset	0.1162	−8.88e-05	−0.00728
	(0.0257)	(0.00707)	(0.00647)
Constant	0.0147**	0.0193*	−0.00213
	(0.00736)	(0.00988)	(0.0106)
Observations	1536	936	600
Number of firms	128	78	50

This table shows the empirical outcomes of the panel estimation for the effect of climate policy uncertainty on firm investment in Chinese energy-related companies. Industry I denotes the production and supply of electricity, heat, gas, and water. Industry II is the mining industry, which takes national standards for the industry classification by China Securities Regulatory Commission (CSRC) as reference. Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

large amount of impairment of the investment funds of these companies. On the other hand, the unpredictability or suddenness of the direction of climate policy changes may disrupt the plans of companies and investors, making companies unable to put their money into specific projects decisively. They are more likely to sit tight and choose their investment strategies more cautiously.

The industry I is mainly engaged in the production and supply of electricity, oil and gas and water. These companies are closely related to the daily life of the people, and the supply-demand relationship of their products will not change significantly under the condition of steady economic development. Therefore, the change of climate policy will not bring precipitate obstacles to them in a short time. On the other hand, even with transformational climate policy changes, these companies will have more coordination space than mining companies. For example, the current trend of developing clean energy is unstoppable, which will substantially impact the main business of mining companies. But these companies of industry I, such as power supply companies, can choose other energy supply companies.

Numerous previous studies on corporate investment have taken GDP as the control variable of the empirical model and shown that high GDP growth rates lead to increased corporate investment [61, 69]. The effects of GDP are positive for both industry I and industry II but only significant for the former, which indicates that economic growth can increase corporate investment, especially for the industry for the production and supply of electricity, heat, gas, and water. From this perspective, hypothesis H2 is valid for energy-related companies as a whole but not for industry II. This may still be related to China's environmental protection policy and the trend of low-carbon development. Economic growth will promote the overall progress of the energy industry, activate their investment activities and create better investment channels. However, due to the existence of regulatory pressure caused by environmental problems, mining companies are facing a more severe living environment.

The estimated coefficients of leverage are − 0.1072, − 0.0158, − 0.0987, respectively, for the whole sample, firms from industries I and II. The coefficients are negative and highly significant except for industry I. This result means that an increase in leverage decreases investment expenditure, which is roughly consistent with prior studies [70]. It is because that capital structure plays a vital role in each business process. Based on the agent theory, when executives work for the benefit of shareholders, they tend to give up some investment projects with a positive NPV when the company already has too much debt [71].

The influence of Tobin's Q is also different by industry. For the companies from industry II, the empirical results indicate that Tobin's Q has a statistically significant positive effect on firm investment expenditure. They note that higher Tobin's Q to some extend captures the future profitability of the company's existing investment projects. However, the empirical result for industry I is not significant. The growth rate of sales also has a very different impact on industries I and II while the growth of assets does not take effect.

4.2.2 Asymmetric impacts of climate policy uncertainty under different market conditions

The panel model has verified the negative linkage between climate policy uncertainty and corporate investment, but this model could only reveal the linear relationship. This section employs the dynamic threshold panel model to examine nonlinearity and possible asymmetry impacts better, and the results are shown in Table 5. Column 1 reports the overall effect of climate policy uncertainty in two industries. Columns 2 and 3 display the empirical results for the industry I and industry II, respectively.

Compared with the static panel model, the dynamic model has a main character that the lag term of the explained variable is added for analysis. From the empirical results, the past investment of the company (L.INV) has a very significant positive effect on the

Table 5 Estimation results of the dynamic threshold panel model

VARIABLES	(1)	(2)	(3)
	Overall	**Industry I**	**Industry II**
L.INV	0.489***	0.502***	0.418***
	(0.0277)	(0.0154)	(0.0236)
L.CPU-below threshold	− 0.0113*	0.0256***	− 0.0365***
	(0.00658)	(0.00445)	(0.00633)
L.CPU-above threshold	−0.00930	0.0214***	−0.0328***
	(0.00579)	(0.00395)	(0.00575)
L.Leverage	−0.0548***	−0.0379***	− 0.0534***
	(0.00886)	(0.00618)	(0.00500)
L.TQ	−0.00174	− 0.00533***	0.00146**
	(0.00111)	(0.00122)	(0.000648)
L.GDP	0.431***	0.325***	0.406***
	(0.0584)	(0.0434)	(0.0606)
L.Sales	0.0175*	−0.0612***	0.0564***
	(0.00920)	(0.0139)	(0.00464)
L.Asset	0.00465	0.0331***	0.00206
	(0.00763)	(0.00563)	(0.00342)
Constant	0.0465***	−0.0156*	0.0874***
	(0.0135)	(0.00851)	(0.0148)
Threshold point	2.023386	1.92843	2.023386
Observations	1536	936	600
Number of firms	128	78	50

This table reports the empirical results of the dynamic threshold model for the effect of climate policy uncertainty on firm investment in Chinese energy-related companies. Industry I denotes the production and supply of electricity, heat, gas, and water. Industry II is the mining industry, which takes national standards for the industry classification by China Securities Regulatory Commission (CSRC) as reference. Standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

current investment expenditure. The other coefficients depict that the impact of climate policy uncertainty is negative and statistically significant in the low-level range (below the threshold point). Consistent with the panel regression results (Table 4), this negative influence is only evident for the total sample pool and industry II companies. This shows that hypothesis H1 is valid for both industry I and industry II, and at the same time, it once again confirms the robustness of our hypothesis H3. This reflects one of the contributions of our article, as the previous literature often only verified a single correlation between uncertainty and corporate investment. Our research found the different performance of sub-industry companies in the energy industry when dealing with climate policies. What's more, the advantages of the threshold model are also reflected because we can see that the entire sample has completely different significant results in the upper and lower threshold ranges.

These results show that the increase in climate policy uncertainty will decrease corporate investment expenditures for the whole piece of Chinese listed companies. Still, when this uncertainty exceeds the threshold, this inhibitory effect disappears instead. In China, most of the listed companies in the energy industry are state-owned enterprises [72]. For Chinese state-owned enterprises, management may be inclined to adopt a more conservative investment strategy when climate policy changes, as they are generally facing less competitive pressure with the support of government forces. For industry II, the upper and lower threshold ranges have significant negative impact coefficients, but it can also be seen that the lower range has a greater impact than the upper range. This may also be because the mining industry will be more directly impacted by climate policy changes, and they're probably own a large number of sunk costs or stranded assets in the future. The dynamic threshold model reflects the nonlinear and asymmetric relationship between climate policy uncertainty and corporate investment under the condition of controlling the past state of the explained variables and demonstrates the relationship between the two in more detail and comprehensively.

In addition, the dynamic threshold regression results of the industry I are quite different from the panel regression results. The second column of Table 5 shows that climate policy uncertainty has a significant positive effect on the investment of companies in Industry I, and it is more obvious in the low-level range. This suggests that industry I companies will increase their investment when climate policy becomes more uncertain. This result is also logical to some extent. As mentioned in Section 4.2.1, the main business of the companies in Industry I is not directly related to activities such as energy mining, but to produce the corresponding products in the form of purchasing energy. So when climate policy changes, the consumer base of their products will not change significantly, but they may look for alternative investment projects, such as clean energy research as a part of long-term development, and so on.

Moreover, the threshold point for the energy-related companies in the mining industry (2.023386) is the same with the whole sample and is larger than that for industry I (1.92843). These results imply that the companies in the industry I was more responsive to the fluctuations in climate policy uncertainty. This outcome may be own to the profitability of the companies in industry I is impacted by both the demand and supply, while the demand for energy mainly impacts the mining industry.

For the GDP term, the results are consistent with those of the panel model, indicating that economic growth positively affects corporate investment and verifying our hypothesis *H3* again. First, this may be explained by the investment opportunities that the company has access to. When the country's GDP growth rate is high, it can be inferred that the country's economy is undergoing rapid development, the possibility of enterprises capturing investment opportunities will increase [73].

In Table 5, the leverage displays significantly negative coefficients of-0.0548, – 0.0379 and – 0.0534 in three columns, thus indicating that the companies with higher debts spend less when investing outside than other companies. The opinions of Jensen [74], Stulz [75], and Grossman and Hart [76] also support that excessive financial leverage will reduce the amount of investment. The estimated coefficients of sale growth are 0.0175, – 0.0612 and 0.0564 for all firms, industries I and II, respectively.

The results of the other control variables are basically consistent with the results of the panel model, and the corresponding coefficients are also significantly different due to the existence of corporate heterogeneity. This shows many differences between the two types of energy industries, and it is worth exploring the different influence mechanisms behind them.

5 Conclusions

In recent years, climate change has become a hot topic globally. Influenced by international organizations or major policymakers and concerned about the national living environment, China has gradually adopted low-carbon cities, carbon markets and other measures to cope with the deterioration of climate conditions in recent years. At the end of 2020, the "carbon peak, carbon neutrality" initiative was put forward, and more detailed regulations were issued to ensure the successful realization of low-carbon transformation. This is both an opportunity and a challenge for the energy industry. This paper explores the relationship between climate policy uncertainty and the investment of two types of energy companies.

We initially understood the negative relationship between climate policy uncertainty and corporate investment through the ordinary panel model with balanced panel data of 128 Chinese listed energy-related companies from 2007 to 2019. Then, through the dynamic threshold model, we further dig out the nonlinear and asymmetric influence between them. For the mining industry, uncertainty about climate policy could significantly reduce corporate investment. For the electricity, heat, gas and water production industries, stronger fluctuations in climate policy could instead boost corporate investment. In addition, we have demonstrated the overall impact of economic growth on corporate investment in the energy industry.

The threshold for the industry I to change its response to climate policy uncertainty is lower than industry II, which indicates that industry I is in fact more sensitive to climate policy changes. It is noteworthy that the effects of climate policy uncertainty do differ significantly between the two different sub-industries. But the same is true, when climate policy uncertainty is in a low-level range, i.e. below the threshold, the impact on corporate investment in these industries is greater, regardless of whether the relationship is positive or negative. The results of this study could help the company managers and policymakers to select appropriate investment decision that maximizes firm value under different climate policy conditions.

This paper still has some limitations in the analysis, which can be improved in future research. The first limitation is the sample period of this study, which starts in 2007 and ends with the latest issued financial statements of the 2019 fiscal year. With a larger sample size, the results could be more robust and efficient. Due to the lack of data, the second limitation is that this study only controls some company characteristics, including leverage, Tobin's Q, company size growth rate, sales growth rate, without the corporate governance's factors, such as the ownership and the characters of the woman on boards. Finally, we could investigate the influence channels between climate policy uncertainty and corporate investment.

Abbreviations

CPU: Climate policy uncertainty; CSRC: China Securities Regulatory Commission; GDP: Gross Domestic Product; Industry I: The industry of production and supply of electricity, heat, gas, and water; Industry II: The mining industry; IPS: Im-Pesaran-Shin panel unit root test; NPV: Net present value; OLS: The least square regression; R&D: Research and development; VIF: The variance inflation factor; I{·}: Indicator function; L.: One period lag; Δ: Sign of difference

Authors' contributions

The slipt of contribution of the work is Xiaohang Ren: Conceptualization, Methodology, Analysis, Software and Writing - Original draft; Yukun Shi: Supervision, Writing – Reviewing and Editing; Chenglu Jin: Writing – Reviewing. The author(s) read and approved the final manuscript.

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Declarations

Competing interests

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