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The impact of carbon risk on real earnings management

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ABSTRACT

Carbon risk has aroused widespread concern in society. With the implementation of carbon policy and the development of carbon market, the research on the impact of carbon risk on corporate financial behavior has become an important academic frontier issue. We examine the impact of carbon risk on firms' real earnings management before and after the Paris climate change agreement, signed by China in 2016. A difference-in-differences model is deployed by using a sample of Chinese A-share listed companies. We find that high-carbon-intensive firms engage in significant upward real earnings management compared to low-carbon-intensive firms to offset the negative impact of carbon risk by conveying the message of good corporate development to investors after signing the Paris Agreement. The above research findings still hold after the robustness tests. Further heterogeneity analyses show that the impact of carbon risk on firms' real earnings management is greater in the sample of non-state-owned firms. The above impact is more significant in firms with weaker corporate governance, implying that strong corporate governance constrains managers from engaging in real earnings management. Therefore, policymakers and regulators should pay attention to the 'strategic response' to earnings management of carbon-intensive firms, taking into account the nature of property rights, corporate governance to reasonably improve the policy design and regulatory direction.

1. Introduction

The U.S. White House has issued the National Climate Assessment, which states that environmental threats could cause significant economic damage and have a major impact on corporate profits, capital markets and household wealth. The Bank for International Settlements pointed out in its book 'The Green Swan' that environmental and climate issues could lead to financial crises, and for the first time suggested that the 'Green Swan event' would become the next capital market exposure. Along

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with global warming and other extreme climate change events, climate change has become an increasingly serious threat to human beings, and countries around the world are united to find strategies to deal with carbon risks. In 2016, 178 parties worldwide signed the Paris Agreement to address global climate change. Under the framework of the agreement, at the 75th session of the United Nations General Assembly, General Secretary Xi Jinping proposed that China should adopt vigorous policies and measures to strive to peak CO_2 emissions by 2030 and achieve carbon neutrality by 2060 to actively undertake the responsibility of a large country and firmly fulfill the commitment to reduce emission.

At present, major developed economies have achieved peak carbon, with the UK, France and Germany achieving peak carbon as early as the 1970s, and the US and Japan achieving peak carbon in 2000 and 2013 respectively. From peak carbon to carbon neutral, it took 71 years for the EU, 43 years for the US and 37 years for Japan to achieve it. China will take 40 years to achieve the emission reduction task that developed countries took $60 \sim 100$ years to achieve. According to the World Bank and the BP World Energy Statistics Yearbook, China's per capita carbon emissions are 1.5 times the global level, and carbon emissions per 10,000 yuan of output value are three times that of developed countries, so China is facing a more serious situation and carbon reduction challenges. In this context, China has implemented stricter climate policies to promote the transition to a low-carbon economy.

The largest contributors of anthropogenic GHG emissions worldwide are GHG-intensive firms from the energy and industry sectors (Cadez & Czerny, 2016), which not only represent the major cause of the problem but are also key to its solution. With the advancement of global climate governance and a low-carbon economy and the tightening of China's climate policy, Chinese enterprises face the challenge of carbon risk in transition to a low-carbon economy. As an important component of environmental risk, carbon risk is commonly used to describe the risk of firms associated with climate change or the use of fossil fuels (Hoffmann & Busch, 2008). *Carbon risk* is defined as the positive and negative impacts of uncertainty in the transition from a brown economy to a green economy on the firm's value. Measuring carbon risk should not be limited to carbon emissions. However, it should also include unpredictable changes to the overall strategy and operations that the firm will suffer during the transition to a green economy (Görgen et al., 2020). The economic consequences of these risks on companies have attracted the attention of the academic community.

Existing western studies on carbon risk mainly use Western capital markets panel data to empirically test the significant negative impact of carbon risk on corporate capital structure, cost of debt, debt maturity, corporate investment, and dividend policy (Balachandran & Nguyen, 2018; Lemma et al., 2020; Nguyen & Phan, 2020; Phan et al., 2022; Pizzutilo et al., 2020). Chinese scholars have also conducted studies on the financial consequences of carbon risk on companies. Some scholars believe that an increase in carbon risk increases the cost of debt (Zhou et al., 2017). However, some scholars believe that a 'U' shaped relationship exists between carbon risk and the cost of debt, and this relationship is mainly reflected in private enterprises (Wang, 2020). In general, the increasing literature at home and abroad believes that a

large carbon risk is associated with adverse outcomes for firms and generates a series of negative signals in the capital market. Therefore, does the negative impact of carbon risk induce companies to undertake real earnings management to mitigate or offset the risk impact?

Real Earnings Management (REM) refers to the unconventional manipulation of a company's daily production and operation activities by its management in order to change the financial information reported, which is the action of manipulating the earnings through normal transactions and operation activities (Ning, 2004). The disclosure of stronger financial results in financial statements is certainly good news, so do firms have an incentive to engage in significant upward real earnings management to send investors the message that the firm is doing well to offset the negative impact of carbon risk on the firm? Specifically, this study examines whether the negative impression of exposing investors to high carbon risk induces firms' managers to use real earnings management to report strong financial performance. From a manager's perspective, boosting short-term earnings during periods of high carbon risk could not only offset bad news (i.e., heightened carbon risk) with good news (i.e., higher earnings) so that the impact of bad news is muted but alleged higher activity levels could also potentially be used as a justification for greater levels of carbon emissions (Amin et al., 2021).

In China, as traditional carbon-intensive enterprises, coal, steel, power and other types of enterprises are often placed in the limelight of environmental protection issues, and their slightest omission in environmental pollution and carbon emission issues will have a huge impact. Predictably, this impact will be amplified with the deepening of environmental awareness. The growing carbon risks faced by carbon-intensive companies are life-threatening for their survival and development. Since policy formulation is ultimately implemented to micro enterprises, which are the main targets of policy regulation, it is essential to study the impact of policy implementation on firms' behavior. As real earnings management directly affects the quality of accounting information and thus the efficiency and effectiveness of market resource allocation, it is important to study the impact of carbon risk on the real earnings management behavior of enterprises for the effective operation of the capital market and the development of China's carbon market.

This study takes the signing of the Paris Agreement, a new global climate change agreement, as an exogenous event and uses a sample of Chinese A-share listed companies from 2010 to 2020 to empirically test the impact of corporate carbon risk on real earnings management in the context of carbon regulation in China. We then consider the special property rights of Chinese companies and corporate governance capabilities in sub-sample studies. Compared to existing studies, the main contributions of this study are as follows: (1) The study can enrich the literature on the factors affecting firms' real earnings management by identifying environmental risk (more specifically, carbon risk) as a complementary influencing factor of real earnings management. (2) Most of the existing studies on carbon risk explore the identification, evaluation, prediction and control of carbon risk from the perspective of risk management, and empirically examine the impact of carbon risk on the cost of capital, financial performance, and enterprise value based on agency theory

(Zhou Zhifang et al., 2017), but few studies have examined whether carbon risk affects the real earnings management of firms. (3) This study distinguishes between state-owned and non-state-owned enterprises and the role of the level of corporate governance in the effect of carbon risk on real management, which further increases the depth of the study and provides a new perspective for research in related fields.

The rest of the article is organized as follows: Section Two discusses the literature review, theoretical analysis and hypothesis development; Section Three describes the data, variables, and econometric models; Section Four provides the empirical analysis and heterogeneity analysis; Section Five presents the robustness tests; Section Six concludes the article and discuss the conclusion.

2. Related references, theoretical analysis and hypothesis development

2.1. Carbon risk and real earnings management

2.1.1. Carbon risk

Carbon risk usually consists of three components: regulatory risk, physical risk, and commercial risk (Dobler et al., 2014). Among them, regulatory risk is the risk associated with current and future carbon regulation policies, and such risks may have a significant impact on the financial performance and cost of capital of a company through additional compliance costs or carbon trading emission credits. Physical risks are those directly related to climate change, such as short- term and long-term droughts, floods, storms, and sea level rise. Finally, commercial risk arises at the firm level including legal, reputational and competitive risks. If a firm is perceived to be environmentally irresponsible, its brand image is likely to be damaged, potentially affecting its future competitive market position and ultimately its future cash flows (Labatt & White, 2007). Massari et al. (2016) pointed out that the level of carbon risk varies in different industries and that carbon risk is mainly present in companies that are directly or indirectly exposed to greenhouse gas emission limits, such as fossil fuel industrial companies or companies that rely heavily on fossil fuels. In the context of the era of global environmental governance, China, as the developing country with the largest carbon footprint, is under enormous energy transition pressure. Accordingly, China has become a signatory to the Paris Agreement and is actively promoting energy efficiency and emission reduction. In the context of the country's active response to the Paris Agreement, the cost of carbon emissions for companies is more likely to be internalized, making carbon risk gradually become an important economic consideration.

Existing domestic and international literature measuring carbon risk includes price indices in the carbon emissions trading market (Lv & Ai, 2021), carbon emission allowances (Oestreich & Tsiakas, 2015; Litterman, 2013), carbon emission levels or changes in emissions (Bolton & Kacperczyk, 2021a, 2021b), carbon emission intensity (Lemma et al., 2020; Phan et al., 2022), penalties received for carbon emission violations (Zhou et al., 2017), and constructed composite index of pollution emission intensity (Görgen et al, 2020). In addition, carbon risk includes uncertainty of future carbon policies, Chinese scholars mostly use environmental regulations on carbon emissions to measure carbon risk, such as carbon emissions trading policies, policies of key cities for air

pollution prevention and control, and China's low-carbon pilot policies, as indicators of carbon risk (Gao, 2022). The 'carbon risk shock' in this paper belongs to the regulatory risk in carbon risk, which refers to the fact that high carbon emitting enterprises face stricter government and media regulation due to the entry into force of the Paris Agreement, which is a 'shock' to high carbon emitting enterprises.

2.1.2. Hypotheses development

As discussed in the previous section, the Paris Agreement is a shock to carbon-intensive businesses. Regarding the political cost motive for firms to engage in earnings management, it mainly refers to the fact that the management of a firm will choose to practice a deeper degree of earnings management behavior when the political cost is higher (Yu, M.X., 2021). Carbon-intensive companies will bear more political costs than the other general business. Watts and Zimmerman introduced political activities into empirical accounting research in 1978 and, based on Contract Theory, went on to propose the political cost hypothesis. They argued that political costs are the expected costs incurred by economic agents as a result of direct or potentially negative political activities, which include but are not limited to industry regulation, fines, and taxation (Watts & Zimmerman, 1978). The signing and subsequent implementation of climate agreements and environmental policies are led by the government and are government actions, which are the same for all companies, but the natural formation of different pollution emissions in different industries leads to significant differences in their impact on different companies (Chen & Zeng, 2018).And because of the specificity of their industries, carbon-intensive companies will become the direct target of environmental regulation policies, and the phenomenon of earnings management for political cost motives will be more common. As the intensity of carbon regulation continues to increase, the regulatory risk also increases. Because regulatory risk is a component of carbon risk, the carbon risk faced by companies is gradually increasing. Carbon intensive enterprises face adverse economic consequences due to the pressure of strict environmental regulation and public media attention, which in turn will affect the particular incentives for managers to manipulate earnings in the context of carbon-intensive firms.

Second, based on the regulatory theory, the stricter the environmental regulation, the greater the regulatory pressure on carbon-intensive enterprises compared to general enterprises, further increasing the credit risk and leading to a tighter financing supply (Wang & Sun, 2021). For external financing suppliers, higher carbon risk means that enterprises may face higher potential litigation risk, for which they will invest more in compliance costs, resulting in a significant decline in their profitability and cash flow. Funds originally set aside for debt service are depleted, raising the risk of debt default. In order to effectively protect their claims and collect their accounts in a timely manner, creditors will impose some constraints on debtor companies to limit the payment of dividends and borrowing of debts, and may even impose financial indicators such as interest coverage multiples, operating capital and total net assets of debtor companies to restrict management's freedom by increasing the cost of violating borrowing contracts (Ma, 2010). Thus, there is a strong incentive for debt covenants to implement excessive earnings management when firms are likely to fail

to meet the requirements of restrictive clauses. Chen, S et al. (2020) found that firms adopt a combination of two types of earnings management strategies when they face financing constraints. Li et al. (2011) concluded empirically that the higher the debt ratio of a firm, in order to avoid default, the stronger the incentive for management to engage in accrual and real earnings management. The above analysis shows that carbon-intensive firms have stronger debt contractual and political cost incentives to engage in real earnings management than other general firms.

So, what are the effects of carbon risk shocks on the real earnings management behavior of carbon-intensive firms and what are the possible mediating channel? Market pressures for reducing greenhouse gas emissions, perceived greenhouse gas-related regulatory uncertainty and environmental strategy focus are important determinants of corporate greenhouse gas reduction strategies (Cadez et al., 2019). The direct effects of carbon risk on firms are manifested in increased uncertainty about firms' future cash flows, increased default risk, and enhanced external supervision due to the uncertainty about future climate change, the use of fossil fuel, future regulation of carbon policies, and technology shocks to firms' business (Hoffmann & Busch, 2008).

There is no uniform answer to the question of how changes in political costs can affect corporate earnings management in the China. While some previous studies support the Western 'political cost hypothesis' that firms choose downward earnings management when political costs rise (Guo, 2014; Ye, 2012), other studies conclude that, contrary to the Western 'political cost hypothesis', firms choose upward earnings management when the government, the 'visible hand', actively intervenes in the market economy. When the 'visible hand' actively intervenes in the market economy, firms choose to manipulate their earnings upward for the purpose of obtaining more government-allocated resources. Lei & Liu (2006) found that the larger the size of the firm, the greater the degree of upward earnings management, using the 1999 annual data of A-share listed firms. Using the 2007 income tax reform as the research background, Li, Z.F et al. (2011) found that the change in interest rates brought about by the income tax reform led to an increase in corporate political costs, which in turn made corporate management tend to use real earnings management to make larger earnings. Therefore, based on the context of the signing of the Paris Agreement, further research is needed to study the impact of carbon risk on corporate real earnings management behavior.

Carbon-intensive companies typically have high fixed costs, such as carbon-related cleanup costs, compliance and litigation costs, and reputational damage costs (Clarkson et al., 2015). Although enhancing resources and production efficiency can reduce pollution, for a rapidly developing nations like China, efficiency improvements are often offset by production increases, resulting in an increase rather than a decrease in overall emissions (Cadez & Guilding, 2017).The increase of the above costs will lead to a decline in financial performance, which leads managers to implement upward real earnings management. Nguyen (2018) found that future climate policies and regulations can lead to a degree of uncertainty for carbon-intensive firms, which can put greater pressure on their financial performance and, in turn, lead to lower financial performance. At this point, managers are more motivated to

implement more covert and flexible upward real earnings management to exaggerate earnings and suppress negative news and to offset the negative news from carbon emissions by providing stakeholder with quality financial reports. The negative effects of carbon risk on firms mainly focus on financial leverage, corporate investment, cost of debt and firms' dividend distribution decisions. For example, Nguyena & Phan (2020) used Australia's ratification of the Kyoto Protocol as a quasi-natural experiment to examine the causal impact of carbon risk on firms' capital structure. They found that the ratification of the Kyoto Protocol led to a decrease in the financial leverage of firms with high carbon emissions, which was achieved through the increased risk of financial distress. For the same question, a similar study was conducted by Wang & Sun (2021) with a sample of Chinese companies, who used China's signing of the Paris Agreement as a quasi-natural experiment to test the impact of carbon risk on firms' financial leverage. Their study found that carbon-intensive firms significantly reduced their financial leverage after signing an agreement. The study further showed that the result was more significant for state-owned enterprises and firms with higher financing constraints, based on the nature of property rights and financing environments specific to China. Using companies listed on the Euro Stoxx 600 Index, Pizzutilo et al. (2020) demonstrated a positive relationship between carbon risk and firms' cost of debt. However, Zhou et al. (2017) showed that the relationship between carbon risk and the cost of debt financing was 'U' shaped, that is to say, there was an 'interval effect' between carbon risk and cost of debt financing, and this effect was mainly reflected in private enterprises, but not significant in state-owned enterprises. Listed companies belonging to carbon-intensive industries in the A-share in China's Shanghai and Shenzhen markets from 2011 to 2015 were used as the research sample in this study. However, Wang (2020) studied the relationship between carbon risk and the cost of debt using different measures of carbon risk for a sample of 76 companies in A-share listed heavily polluting industries from 2012 to 2018 and found that increased carbon risk can raise the cost of debt for companies, similar to the results of foreign studies. Phan et al. (2022) concluded that carbon risk harmed corporate investment and that this risk reduced the corporate investment efficiency by analyzing a cross-country sample of 14,874 companies from 2002 to 2017. In addition, carbon risk impacted firms' dividend distribution decisions. Balachandran & Nguyen (2018) found that after the ratification of the Kyoto Protocol, firms in industries with higher carbon emissions were less likely to pay dividends and had lower dividend payout rates relative to those with low carbon emissions.

The enactment of carbon regulation policy will lead to external monitoring effect, which will increase the cost of real earnings management, and thus reduce the degree of real earnings management. (Hu et al., 2022). Under the guiding effect of the relevant policies, carbon intensive industries become the focus of social media attention and government regulation, which can effectively restrain the management's earnings management behavior. First, in the capital market, securities analysts and institutional investors are important subjects to monitor the management of listed companies, and they will be keen to perceive the possible self-interest of the management, so as to monitor the management of enterprises more strictly and restrain their opportunistic

behaviors. Second, as an important information medium outside the enterprise, the news media can effectively monitor the management behavior of listed companies and play its corporate governance role through monitoring, reputation and market pressure mechanisms (Tian et al., 2016). The spotlight effect brought by media attention can effectively reveal the existing problems of enterprises concerned and restrain the management's behavior of manipulating accounting information. Thirdly, accounting regulation by government departments has a facilitating effect on the quality of accounting information of listed companies (Li, 2007). Under the policy guidance, the government will take the initiative to strengthen the accounting supervision and penalties for non-compliance of carbon-intensive enterprises, which can strongly monitor and restrain the management behavior and thus reduce the degree of corporate earnings management.

Reviewing the literature, we found that there are few literature studying the direct effect of carbon risk on firms' real earnings management, but the studies on environmental regulation on firm performance, motivation of real earnings management and the economic consequences of carbon risk to firms provide references for this paper. The research mainly has the following characteristics: (1) Some scholars have studied the relationship between political cost, financial performance, external supervision and corporate earnings management., but no scholars have yet studied carbon risk and corporate earnings management, so further improvement is needed to fill the gap in the research field. (2) Existing research on carbon risk mainly uses panel data to empirically test the impact of carbon risk on corporate capital structure, cost of debt, debt maturity, corporate investment, dividend policy. However, few scholars have studied whether real earnings management, a financial reporting decision, is related to carbon risk.

The potential impact of carbon risk on firms' earnings management is unclear. Firstly, based on the political cost hypothesis, the increasing carbon risk faced by enterprises will lead to the rise of political cost, and enterprises will choose to manipulate earnings upward for the purpose of obtaining more government resources. Secondly, carbon-intensive firms usually have high fixed costs, which will lead to the decline of financial performance and encourage managers to implement upward real earnings management. Finally, the carbon regulation policies will lead to external supervision effect, increase the cost of real earnings management of enterprises, and then reduce the degree of real earnings management of enterprises. Based on the above analysis, this paper proposes the following hypothesis:

H1a: Carbon risk is positively related to upward REM.

H1b: Carbon risk is negatively related to upward REM.

2.2. Carbon risk, nature of property rights, and real earnings management

Previous scholars have argued that firms with different natures of ownership have different choices in implementing real earnings management behaviors. For example, Xie & Liao (2018) found a stronger positive relationship between controlling shareholders' equity pledging practices and upward manipulation of earnings for real

earnings management in non-state holding companies. In addition, Ou & Zhao (2022) found that the positive relationship between managerial overconfidence and real earnings management is greater in non-state firms than in-state firms when board independence is high.

Inspired by the above literature, this study argues that, on the one hand, after the Paris Agreement is signed, the government will highlight carbon regulation, and state-owned enterprises will be more sensitive to the policy; thus, state-owned enterprises will be able to adjust their operation and investment activities promptly to reduce the impact of carbon risk. At this time, non-state-owned enterprises, which may become targets of government control, face greater carbon risk and have stronger incentives to engage in upward real earnings management behavior. On the other hand, since managers in state-owned enterprises are more likely to originate from the government, they are more cautious about implementing real earnings management than managers of non-state-owned enterprises. Therefore, we propose the following hypothesis:

> H2: The positive relationship between carbon risk and real earnings management is stronger for non-state-owned enterprises.

2.3. Carbon risk, the corporate governance level, and real earnings management

As mentioned, real earnings management harms the long-term value of a firm. Bhojraj et al. (2009) showed that reducing discretionary expenses to obtain higher short-term earnings led to poor performance of firms in the future. Similarly, Cohen & Zarowin (2010) and Kothari et al. (2016) found under-performance following seasoned equity offerings (SEO) to be greater for firms that engage in REM at the time of SEO. Existing studies have found that stronger internal corporate governance can moderate managers' REM behavior and that well-governed firms are less likely to engage in activities that reduce shareholder value (Chen et al., 2015; Cheng et al., 2016; Fang & Jin, 2011; Huang et al., 2020). Therefore, strong corporate governance acts as a constraint on managers' tendency to make value-destroying decisions (Jensen & Meckling, 1976; Shleifer & Vishny, 1997). Corporate governance system comprises a range of actors and/or mechanisms, including the board of directors, the management board, the audit committee, the internal audit function, the regulators and others (Bajra & Cadez, 2018b). According to Bajra & Cadez(2018b), they found that audit committee monitoring effectiveness and competencies are positively associated with financial reporting quality. In addition to this, they also found that internal audit function quality and board of directors' quality, two key mechanisms in the corporate governance mosaic, are important mechanisms for deterring earnings management (Bajra & Cadez 2018a).

Based on these findings, we expect that the positive relationship between carbon risk and upward real earnings management will be weaker in firms with higher levels of governance. Therefore, we propose the following hypothesis:

> H3: The positive association between carbon risk and real earnings management is weaker for firms with strong corporate governance.

3. Research design

3.1. Data and sample selection

Our sample consists of firm-year observations of all listed companies that issues RMB common stocks in China from 2010 to 2020. As we all know, China is under pressure to reduce carbon emissions, and has implemented more stringent environmental regulations and policies. Since companies are both the main contributors to carbon emissions and in fact the key to the problem, it has reality significance to study the economic consequences of carbon risk for companies in China. After removing the missing values, we obtained 22,357 observations. All the financial information at the firm-level is acquired from the Chinese Stock Market and Accounting Research Database (CSMAR). After the initial determination of the analysis sample, the samples were further processed according to the following steps: (1) Companies with missing financial data were excluded which can ensure data integrity; (2) ST, ST*, and PT companies were excluded, since these firms are facing a high risk of being delisted and their stock is traded with stricter trading rules. (3) Financial companies were excluded to take into account the specificity of the financial industry and the differences in accounting methods; (4) To alleviate the impact of extreme value, all continuous variables were winsorized at the 1% and 99% quartiles by year.

3.2. Difference-in- Differences model specification

Currently, the following two challenges are prevalent in empirical studies on the impact of carbon risk on firms. The first is endogeneity. Carbon risk and real earnings management may be determined by other neglected firm characteristics, leading to bias and inconsistency in parameter estimation. The second challenge is the bias caused by the small sample. In particular, only a small fraction of listed companies in China disclose their data on carbon emissions through annual reports or social responsibility reports; therefore, obtaining a sufficient sample of carbon emissions data is a big challenge.

First, China's signing of the Paris Agreement in 2016 provides a good quasi-natural experimental condition for this study. The Paris Agreement is the third landmark international legal document in human history that deals with climate change after the United Nations Framework Convention on Climate Change and the Kyoto Protocol, which built the general pattern of global climate governance after 2020. In addition, China will take corresponding measures to actively fulfill the Paris Agreement requirements after its signing. Therefore, it is reasonable to use the Paris Agreement as an external shock for carbon-intensive firms. Using this policy change allows us to establish the causal impact of carbon risk on firms' real earnings management. Second, to address the small sample bias, we rely on the polluting nature of a firm's industry. Specifically, we define carbon-intensive and low-carbon emitting firms based on the industry's relative carbon emissions and energy consumption levels. The Paris Agreement is implemented for carbon-intensive firms. It does not affect low-carbon emitting firms, so carbon-intensive and low-carbon emitting firms are good experimental and control groups.

Under this condition, this paper uses a Difference-in- Differences model (DID) to identify the causal relationship between carbon risk and firms' real earnings management. The DID model largely avoids the reverse-causality problem, which can better exclude the interference of factors other than policies on the estimation results, and the time and industry fixed effects alleviate the omitted variable problem. Our baseline DID model has the following form:

$$REM_{i,t} = \beta_0 + \beta_1 polluter_{i,t} + \beta_2 post_{i,t} + \beta_3 polluter_{i,t} * post_{i,t}$$
$$+ \sum \beta Conrtol_{i,t} + IndustryFE + YearFE + \varepsilon_{i,t}$$

3.3. Variable definition

3.3.1. Measurement for the real earnings management

The explained variable is REM. Referring to Roychowdury (2006) and Cohen and Zarowin (2010), we measure real earnings management based on Equations (1)–(4). First, we estimate the residuals by regressing Equations (1)–(3) by industry and year to calculate the firm's abnormal discretionary expenses (AB_DISEXP), abnormal product costs (AB_ PROD), and abnormal net operating cash flows (AB_CFO). Based on these three indicators, a composite indicator (REM) is constructed according to Equation (4) to measure the extent of real earnings management that manipulates earnings upward. The higher the REM value, the higher the degree of an upward earnings adjustment through real activity this year.

$$DISEXP_{i,t}/A_{i,t-1} = a_0 + a_1(1/A_{i,t-1}) + a_2(S_{i,t-1}/A_{i,t-1}) + \varepsilon_{i,t}^{disexp} \tag{1}$$

$$PROD_{i,t}/A_{i,t-1} = a_0 + a_1(1/A_{i,t-1}) + a_2(S_{i,t}/A_{i,t-1}) + a_3(\Delta S_{i,t}/A_{i,t-1})$$
$$+ a_4(\Delta S_{i,t-1}/A_{i,t-1}) + \varepsilon_{i,t}^{prod} \tag{2}$$

$$CFO_{i,t}/A_{i,t-1} = a_0 + a_1(1/A_{i,t-1}) + a_2(S_{i,t}/A_{i,t-1}) + a_3(\Delta S_{i,t}/A_{i,t-1}) + \varepsilon_{i,t}^{cfo} \tag{3}$$

$$REM = AB\_PROD - AB\_DISEXP - AB\_CFO \tag{4}$$

In these equations, $\varepsilon_{i,t}^{disexp}$, $\varepsilon_{i,t}^{prod,}$ and $\varepsilon_{i,t}^{cfo}$ from Equations (1)–(3) denote AB_ DISEXP, AB_PROD, and AB_CFO, respectively, which are regression residuals from Equations (1)–(3). The other variables involved in Equations (1)–(3) are defined in Table 1.

3.3.2 Measurement for the carbon risk

This study uses the signing of the Paris Agreement in China in 2016 as a quasi-natural experiment. It constructs an interaction term (polluter * post) to capture the effect of carbon risk on firms' REM. Polluter denotes whether the firm is in the experimental group: carbon-intensive firms (experimental group) are 1, and other firms (control group) are 0. The State Council issued *The Notice on the Pilot Work of Carbon Emission Trading* in 2011, which proposed the gradual implementation of a

Table 1. Definition of variables of Equations (1)–(3).

Variable	Definition
$DISEXP_{i,t}$	The sum of selling expenses and administrative expenses
$A_{i,t-1}$	The total assets in year t-1
$PROD_{i,t}$	The sum of operating cost and the increase of inventory cost
$S_{i,t}$	Revenue from main business
$\Delta S_{i,t}$	Revenue from main business's difference between the current year and the previous year
$CFO_{i,t}$	The operating cash flow

Source: CSMAR.

Table 2. Variables definitions.

Variable	Definition
REM	REM = AB_PROD-AB_DISEXP-AB_CFO
polluter	Dummy variable, which represents whether a firm is carbon intensive firms
post	Dummy variable, whether the year is after 2016 or not
pollpost	pollpost = polluter*post
size	Natural logarithm of total assets
ROA	Net profit / total assets
leverage	Financial leverage, which is the ratio of total liabilities to total assets
tobinq	The ratio of market value of assets to book value of assets
growth	Sales growth rate from year t to year t-1
loss	Dummy variable to denote whether a firm has negative net earnings
top1	The shareholding of the largest shareholder
nature	Dummy variable, equals one if a firm's actual controller is government
big4	Dummy variable, equals one if a firm's annual report is audited by the big4 auditors, including Deloitte, Ernst & Young, KPMG, and PwC.
msl	The shareholding of management
analysts	Natural logarithm of one plus the number of analysts following the firm
insthold	The shareholding of institutional shareholders

Source: CSMAR.

carbon emissions trading market. Eight industries–petrochemical, chemical, building materials, iron and steel, non-ferrous, paper, electricity, and aviation–are gradually included in this market. Thus, this study defines listed companies in the above eight industries as carbon-intensive enterprises and listed companies in other industries as low-carbon-emitting enterprises. Post denotes the time variable of China signing the Paris Agreement, with 1 for the year after the event and 0 for other years. This study focuses on β3: the coefficient of polluter*post. If β3 is significantly positive, carbon risk can strengthen real earnings management behavior. Thus, H1a is verified.

3.3.3. Measurement for the control variables

Following previous studies such as Xie & Liao (2018), Chen et al. (2018), He et al. (2019) and Liu et al. (2018), this study selects ROA, size, Tobin's Q, leverage, growth, loss, top1, nature, big4, msl, analysts, and insthold as control variables. The industry dummy variable and year dummy variable is also set to control industry and year effects. The detailed definitions of the control variables are presented in Table 2.

4. Empirical result

4.1. Description statistics

Table 3 presents the descriptive statistics of the primary variables. The standard deviation of REM is 0.178, the maximum value of REM is 0.468, and the minimum value

Table 3. Summary statistics.

Variable	N	mean	p50	sd	min	max
REM	22537	−0.004	0.006	0.178	−0.612	0.468
post	22537	0.563	1.000	0.496	0.000	1.000
polluter	22537	0.273	0.000	0.445	0.000	1.000
pollpost	22537	0.143	0.000	0.350	0.000	1.000
size	22537	22.288	22.102	1.277	19.977	26.277
leverage	22537	0.439	0.435	0.203	0.059	0.891
ROA	22537	0.035	0.035	0.062	−0.286	0.206
tobinq	22537	2.046	1.614	1.320	0.865	8.865
growth	22537	0.418	0.144	1.113	−0.682	8.156
loss	22537	0.100	0.000	0.300	0.000	1.000
salary	22537	0.007	0.005	0.007	0.000	0.038
top1	22537	34.224	32.046	14.795	8.748	74.890
msl	22537	11.621	0.241	18.338	0.000	70.696
analysts	22537	1.485	1.386	1.194	0.000	4.331
insthold	22517	44.091	46.246	24.180	0.000	101.140
big4	22517	0.059	0.000	0.236	0.000	1.000

Source: CSMAR.
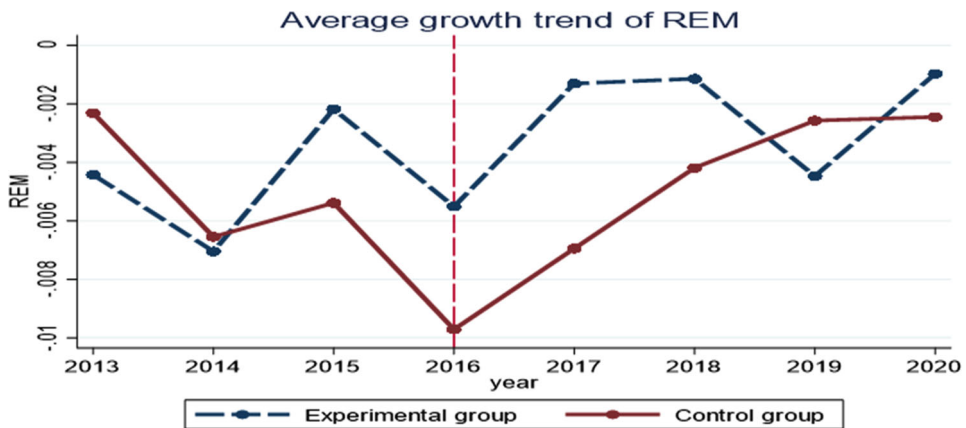
Figure 1. Time trends in real earnings management for carbon-intensive and low-carbon emitting firms.
Source: CSMAR.

of REM is 0.612, which shows that the real earnings management of sample companies has a large variation. The polluter has a mean of 0.273, indicating that treated firms occupy approximately 27.3% of the total sample. The mean value of the pollpost is 0.126, indicating that firms with high carbon emissions after the Paris Agreement account for 12.6% of the total observations. In terms of the main control variables, the mean value of firm size is 22.288, and the corresponding standard deviation is 1.277, indicating some differences in size among firms. Leverage has a mean of 0.439, indicating that the overall debt level of firms remains reasonable.

4.2. Regression analysis

4.2.1. Parallel trend test

One of the prerequisites for the validity of the DID is that the experimental and control groups satisfy the parallel trend assumption before the event. Therefore, to verify
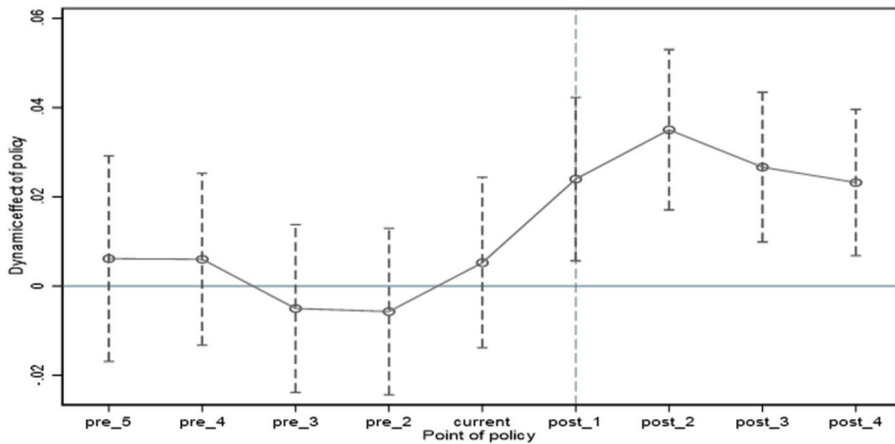
Figure 2. Trends in REM in carbon-intensive and low-carbon emitting firms for the event research method.
Source: CSMAR.

the appropriateness of the model used in this study, a parallel trend test is conducted for the experimental and control groups. As shown in Figure 1, before the Paris Agreement (from 2010 to 2015), the experimental group (carbon-intensive firms) and control group (non-carbon-intensive firms) showed a trend of falling, rising, and then falling in the average growth trend of real earnings management. Whereas after 2016, the REM of the experimental group showed a rising, falling, then decreasing trend, and the REM of the control group showed a rising trend all the time. The trends in the two groups showed a significant difference. Therefore, the DID model used in this study is consistent with the premise of a parallel trend.

In addition, the dynamic effects of the policy between years are also presented using the event research method (the mid-point in each vertical line is the parameter estimate and the two endpoints are confident intervals at the 95% confidence level). As shown in Figure 2, there is no significant difference between the two groups before signing the agreement. However, after signing the agreement, the coefficients are significantly positive. This result satisfies the premise of the parallel trend hypothesis. The above results indicate that the true surplus management of carbon-intensive and low-carbon emitting firms in this study satisfies the parallel trend hypothesis.

4.2.2. Regression analysis

Column (1) of Table 4 presents the empirical regression results for H1. The coefficient of polluter is −0.028, which passes the significance test at the 1% level, indicating that the average difference between the REM of low-carbon-firms and high-carbon emitting firms before the Paris Agreement is 0.028. The number of low-carbon emitting firms engaging in upward REM is greater from 2010 to 2015. We need to pay attention to the coefficient of the term pollpost; as we can see, the coefficient of pollpost is 0.024, which is significantly positive at a 1% level of significance. The empirical results show that the carbon-intensive firms after the Paris Agreement (firms with high carbon risk) have a greater degree of upward adjustment in their real earnings management. Thus, H1a is verified.

Table 4. Carbon risk and real earnings management.

	(1) REM	(2) State-owned enterprises REM	(3) Non-state-owned enterprises REM
post	−0.034***	−0.018**	−0.032*
	(−4.830)	(−2.409)	(−1.743)
polluter	−0.028***	−0.014	−0.047***
	(−3.981)	(−1.543)	(−4.134)
pollpost	0.024***	0.003	0.032***
	(5.341)	(0.520)	(4.822)
size	0.007***	0.015***	0.000
	(3.831)	(6.068)	(0.073)
leverage	0.074***	0.058***	0.091***
	(9.858)	(5.235)	(8.795)
ROA	−1.008***	−0.951***	−1.060***
	(−31.166)	(−17.001)	(−26.139)
tobinq	−0.007***	−0.0002	−0.0101***
	(−5.624)	(−0.074)	(−6.389)
growth	−0.0004	−0.0009	−0.0002
	(−0.293)	(−0.433)	(−0.095)
loss	−0.090***	−0.050***	−0.121***
	(−18.755)	(−7.711)	(−17.404)
salary	−1.379***	−0.588	−1.726***
	(−5.807)	(−1.222)	(−6.052)
top1	0.0002*	0.0004***	0.0000
	(1.866)	(2.763)	(0.359)
msl	−0.0004***	−0.002***	−0.0003***
	(−3.982)	(−2.965)	(−2.688)
analysts	−0.025***	−0.021***	−0.027***
	(−19.534)	(−10.451)	(−15.935)
insthold	−0.0004***	−0.0008***	−0.0003**
	(−5.054)	(−5.514)	(−2.423)
big4	−0.040***	−0.027***	−0.065***
	(−7.945)	(−4.682)	(−7.021)
nature	0.021***	–	–
	(7.498)		
_cons	−0.054	–	–
	(−1.401)	(−4.531) (1.989)	
F	60.974	99.838	41.884
N	22103	8898	13205
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes

*, **, *** represent the coefficient is significant at the 10%, 5%, and 1% level, respectively.
Source: CSMAR.

4.3. Analysis of heterogeneity

In the above main regressions, the results show that carbon risk significantly increases the degree of REM in firms that manipulate their earnings upward. Based on the theoretical analysis in the second section of this study, we further reason that carbon risk affects the REM of different firm types. Therefore, the next step is to empirically test this judgment by dividing the overall sample into different subsamples according to the nature of the ownership and corporate governance. We then conduct regression tests on each subsample based on the basic regression model.

4.3.1. Nature of property rights

As shown in H2, state-owned enterprises have a higher sensitivity to national policy implementation, and executives in state-owned enterprises have a higher degree of

Table 5. Carbon risk, level of corporate governance, and real earnings management.

	(1) High corporate equity checks and balances	(2) Low corporate equity checks and balances	(3) Big4 audit	(4) Non-big4 audit	(5) High analyst attention	(6) Low analyst attention
plluter	−0.031***	0.013	−0.009	−0.031***	−0.030***	0.016
	(−4.270)	(0.454)	(−0.515)	(−4.014)	(−4.234)	(0.530)
post	−0.036***	−0.021	0.0518**	−0.0363***	−0.0351***	−0.0228
	(−4.674)	(−1.280)	(2.016)	(−5.036)	(−4.595)	(−1.389)
pollpost	0.021***	0.036***	−0.012	0.025***	0.020***	0.038***
	(4.355)	(3.312)	(−0.747)	(5.342)	(4.177)	(3.571)
Control	Yes	Yes	Yes	Yes	Yes	Yes
r2	0.199	0.137	0.395	0.182	0.199	0.136
F	56.502	6.615	.	54.846	56.061	6.927
N	19228	2875	1306	20797	19100	3003
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes

*, **, *** represent the coefficient is significant at the 10%, 5%, and 1% level, respectively.
Source: CSMAR.

prudence in implementing REM. To test H2, we divided the whole sample into a sample group of state-owned enterprises and a sample group of non-state-owned enterprises based on the nature of property rights. The regression results are shown in columns (2) and (3) of Table 4. The coefficient of pollpost is significant only in the sample of non-state-owned enterprises. This indicates that non-state-owned carbon-intensive firms prefer to engage in upward REM when the carbon risk increases. This result validates H2.

4.3.2. Level of corporate governance
As mentioned earlier, strong corporate governance acts as a constraint on the tendency of managers to make value-destroying decisions. Therefore, if a firm has a high level of corporate governance, it may inhibit management's tendency to engage in REM and weaken the effect of carbon risk on real earnings management. To test this assumption, we use three indicators–corporate equity checks and balances (share), high-quality audit (big4), and the number of analysts tracking (attention)–to measure the corporate governance level of firms. Specifically, a share is equal to the sum of the shareholdings of the second to fifth largest shareholders divided by the shareholding of the first largest shareholder; Big4 is a dummy variable that takes the value of 1 when the firm's auditor for the year is an international Big 4, and 0 otherwise; Attention equals the number of analysts following the firm for the year. We divide the full sample into high equity checks and balances and low equity checks and balances groups, high analyst attention and low analyst attention groups based on the sample median of share and attention. We then divide the sample into Big 4 and non-Big 4 audit groups based on whether Big4 equals 1. We expect that carbon risk will lead to a greater degree of upward real earnings management in firms with the worse corporate governance (i.e., lower equity checks and balances, non-Big 4 audits, and low analyst attention).

The test results are presented in Table 5. Columns (1)–(2), (3)–(4), and (5)–(6) show the results of the subgroup tests that measure the level of corporate governance using equity checks and balances, the high-quality audits, and analyst attention,

respectively. The results show that although the coefficient of pollpost is significant in columns (1) and (2) and columns (5) and (6), the coefficient of pollpost is larger in columns (2) and (6) than in columns (1) and (5). The coefficient of pollpost is not significant in the Big 4 audit group in column (3), whereas in the non-Big 4 audit group in column (4), the coefficient of pollpost is significant at the 1% level of significance. Thus, it can be concluded that the effect of carbon risk on firms' upward adjustment of REM is greater in firms with poor corporate governance, indicating that effective corporate governance, to some extent, can inhibit the irrational behavior of management under the influence of carbon risk and weaken the effect of carbon risk on firms' REM, confirming the proposed H3.

5. Robustness checks

5.1. Placebo test

To exclude the influence of other policy and stochastic factors on the findings: this study uses the counterfactual method to verify the causal relationship between carbon risk and firms' real earnings management (Minggui Yu et al., 2021). Specifically, forthe counterfactual test, we take the years 2010-2015, when the Paris Agreement has not yet been implemented, as the sample interval and assume 2013 and 2014 as the signing years. The regression results are shown in columns (1) and (2) of Table 6 for pollpost[false] . We can observe that none of the coefficients of pollpost[false] are significant, indicating that the results of this study are robust, driven by China's signing of the Paris Agreement in 2016 rather than by other policy or stochastic factors.

Meanwhile, to increase the credibility of the conclusions, we then performed a placebo test by randomly assigning the experimental and control groups. Specifically, we randomly selected some samples originally involved in the regression as the experimental group and the remaining samples as the control group. Then, we created a new interaction term Polluter*post according to the new experimental and control groups and bring it into the model for regression, recording the coefficients and t-values of the interaction term. The simulation experiments are repeated 500 times according to the above method. Table 7 shows the standard deviation, mean, median, and each percentile of the coefficients and t-values of Polluter*post. We can conclude that the t-values of the coefficients of Polluter*post are not significant, except for the 5th percentile. The results indicate that the findings of this study are due to random factors.

5.2 Propensity score matching(PSM) and DID

The experimental and control groups in this study are high-carbon-intensive and low-carbon-emitting firms. However, the REM of these two firm types may be inherently different, leading to sample selection bias. Since PSM-DID can effectively mitigate endogenous issues, this study uses the propensity score assignment to control potential endogenous issues. First, we performed no-release matching with all control variables in the model as matching variables and then matched the experimental and control groups based on the scores with nearest-neighbor matching, which can test

Table 6. Placebo test1.

	(1) 2013 REM	(1) 2014 REM
post^{false}	−0.029***	−0.027***
	(−3.243)	(−3.363)
polluter	−0.010	−0.012
	(−0.965)	(−1.296)
pollpost^{false}	−0.011	−0.008
	(−1.583)	(−1.229)
size	0.0084***	0.0084***
	(3.162)	(3.167)
leverage	0.055***	0.055***
	(4.633)	(4.624)
ROA	−1.406***	−1.406***
	(−22.660)	(−22.666)
tobinq	−0.009***	−0.009***
	(−4.701)	(−4.677)
growth	−0.001	−0.001
	(−0.521)	(−0.527)
loss	−0.087***	−0.087***
	(−12.467)	(−12.446)
salary	−0.913**	−0.912**
	(−2.318)	(−2.314)
top1	0.000**	0.000**
	(2.048)	(2.064)
msl	−0.0001	−0.0001
	(−0.461)	(−0.475)
analysts	−0.024***	−0.024***
	(−10.998)	(−10.974)
insthold	−0.0004***	−0.0004***
	(−2.787)	(−2.810)
big4	−0.043***	−0.043***
	(−5.654)	(−5.655)
nature	0.009**	0.009**
	(2.001)	(1.997)
_cons	−0.081	−0.081
	(−1.400)	(−1.390)
r2	0.208	0.208
F	33.551	33.518
N	9727	9727
Year	Yes	Yes
Industry	Yes	Yes

*, **, *** represent the coefficient is significant at the 10%, 5%, and 1% level, respectively.
Source: CSMAR.

Table 7. Placebo test2.

Variable	S.D.	Mean	P5	P25	P50	P75	P95
Polluter*post Coefficient	−0.002	0.006	−0.011	−0.005	−0.002	0.002	0.007
T-Value	−0.335	1.082	−2.053	−1.018	−0.321	0.391	1.441

Source: CSMAR.

the effect of matching. The test results showed that the % bias of all covariates after matching was less than 10%. Finally, the samples involved in the matching were brought into the model for regression, and the results are shown in Table 8. It can be seen that the results did not change substantially after matching and still support H1a.

Table 8. The result of PSM-DID.

	(1) REM
treated	−0.028***
	(−3.968)
post	−0.033***
	(−4.776)
treated*post	0.023***
	(5.311)
size	0.007***
	(3.816)
levarage	0.074***
	(9.908)
ROA	−1.006***
	(−31.054)
tobinq	−0.007***
	(−5.643)
growth	−0.001
	(−0.607)
loss	−0.090***
	(−18.767)
salary	−1.417***
	(−5.944)
top1	0.0002*
	(1.947)
msl	−0.0004***
	(−3.940)
analysts	−0.026***
	(−19.605)
insthold	−0.0004***
	(−5.104)
big4	−0.040***
	(−7.948)
nature	0.022***
	(7.540)
_cons	−0.050
	(−1.298)
r2	0.190
F	61.047
N	22076
Year	Yes
Industry	Yes

*, **, *** represent the coefficient is significant at the 10%, 5%, and 1% level, respectively.
Source: CSMAR.

6. Discussion and conclusion

This study examined the impact of carbon risk on firms' real earnings management. We found that carbon risk is positively associated with upward real earnings management, and the above result still stands after parallel trend tests and placebo tests.

Furthermore, we found that the positive effect of carbon risk on REM in non-state enterprises is stronger after the Paris Agreement. By emphasizing the role of corporate governance in REM behavior, we also found that the relationship between carbon risk and REM is stronger in firms with low equity checks and balances, non-Big 4 audits, and low analyst attention.

The findings of this study support the positive relationship between political costs and upward real earnings management proposed by some scholars. When firms are exposed to greater carbon risk, they bear more political costs, which in turn affects managers' motivation to manage their earnings.

This finding is worth considering: Chen et al. (2022), based on Information Asymmetry Theory, examined the impact of environmental regulations on firms' real and accrued earnings management using the DID approach and found that stricter environmental regulations were negatively related to real earnings management. Based on The Political Cost Hypothesis, Huang & Zhou (2021) found that after the implementation of the new Environmental Protection Law, heavily polluting firms engaged in significant upward accrual earnings management and real earnings management compared to non-polluting firms. Both studies examine the relationship between environmental regulation and firms real earnings management, but yield opposite results. Based on the above studies, this paper specified the study to carbon-intensive firms and replaced the independent variable of environmental regulation with carbon risk. Carbon risk refers not only to the regulatory risk associated with stricter carbon regulation policies, but also to physical and commercial risk. The study found that carbon risk promotes upward real earnings management by firms. We argue that different types of firms respond differently to environmental regulatory policies and that firms react differently to different environmental regulatory policies. As Li, H., & Li, B. (2019) argued, there is no simple linear relationship between environmental regulation intensity and industrial economic green transformation, and there is a threshold effect in environmental regulation intensity and industrial green transformation. This paper enriches the research on the impact of environmental regulations on the quality of corporate earnings. In contrast to the findings of Chen et al.(2022), the results of this paper demonstrate that environmental regulations do not all incentivize firms to provide better quality of earnings.

On the other hand, carbon risk can improve the carbon performance level of enterprises and has a positive impact on carbon emission reduction effect. First of all, from the perspective of the impact of government environmental regulations on carbon emission reduction, Li et al. (2020) found that government intervention in the environment could effectively reduce the rate of carbon emission. Wu et al. (2021) tested the carbon emission reduction effect of the market and found that government administrative intervention in the carbon market has a significant positive impact on the carbon emission reduction effect. Secondly, based on the pressure of economic stakeholders, the rise of low-carbon economy also forces enterprises to take measures to maintain their legal status and competitive advantage. In addition to government supervision, external factors affecting corporate carbon performance also include pressure from economic stakeholders (mainly including investors, competitors and consumers) (Ashraf et al., 2021; Cai & Zhou, 2014; Cordeiro & Tewari, 2015; Zhou et al., 2020). After the signing of the Paris Agreement, public awareness of carbon risk has been significantly enhanced, which will also have an impact on the carbon performance of enterprises. Due to the pressure of the public and the needs of their own business and development strategies, enterprises in global production and tend to have strong environmental awareness and adopt positive attitudes and behaviors to conduct environmental governance, which will significantly improve their own carbon performance (Cheng et al., 2018). Finally, in order to respond to the carbon information required by stakeholders and the public, it is increasingly important to disclose carbon information. Qian & Schaltegger (2017) have found that changes in the level

of carbon information disclosure of enterprises are positively correlated with subsequent changes in carbon performance. Alsaifi (2021) obtained the same result through empirical research, that is, strengthening the carbon information disclosure of enterprises is conducive to improving the carbon performance in terms of greenhouse gas emissions.

Therefore, it can be seen that, on the one hand, the signing of Paris Agreement increases the carbon risk, and a series of negative impacts on enterprises will make them carry out real earnings management to a certain extent. On the other hand, it will play a positive role in firms' carbon performance and carbon emission reduction. It is worth considering that perhaps a small increase in REM is an acceptable cost in order to protect the planet and society, that is, to reduce pollution and protect the planet for future generations.

Based on the conclusions above, this study has the following suggestions: First, China should firmly fulfill the Paris Agreement commitments, although strict carbon regulation policies will make carbon-intensive enterprises face greater carbon risk, which can make firms have stronger incentives to carry out REM of upwardly adjusted earnings and reduce the quality of corporate accounting information to some extent. However, enterprises' REM behavior will be suppressed through high-quality internal control and external supervision. Perhaps a small increase in REM is an acceptable cost to secure much more important benefits for the planet and the society, i.e., pollution reduction and preserving the planet for future generations. Therefore, China should uphold the concept of the 'Community of Human Destiny' and take up its responsibilities and obligations in global environmental governance. Second, the government and regulators should pay attention to the 'strategic' response to REM in high-carbon-intensive enterprises. Governments should consider the nature of property rights, corporate governance capabilities, and other factors to improve the design of the system and the direction of regulation. Simultaneously, the government should take measures to encourage and guide carbon-intensive enterprises to make green transformations to prevent risks. Furthermore, government policies should not only focus on the strength of environmental regulations, but adopt different environmental policies in different industrial sectors. Third, carbon-intensive enterprises facing the risks brought by the uncertainty and complexity of changes in natural environmental factors should actively face them, turn the risk challenges into strategic opportunities, and actively seek opportunities for strategic transformation. Finally, investors should enhance their risk awareness by considering the ability of firms' internal and external governance, paying attention to the proportion of institutional investors and the number of analysts tracking to comprehensively judge the quality of corporate earnings information and thus make better investment decisions.

This paper herein may have some limitations are as followed. Firstly, the conclusion suggests that firms choose upward earnings management behavior when carbon risk increases, but how is this effect transmitted? This paper lacks in-depth research on this aspect, and the mechanism of carbon risk's influence on firms' real earnings management will be the direction of further research in this paper. Secondly, the article adopts the data of carbon-intensive listed companies from 2010-2020 as the sample and controls the industry and annual dummy variables for study, but does not

consider the factor that there may be differences in carbon risk and the level of corporate earnings management in different regions, such as the east, middle and west, etc. In the future, the differences in the influence of carbon risk on the real earnings management behavior can be explored by different regions.

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Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

References

Alsaifi, K. (2021). Carbon disclosure and carbon performance: Evidence from the UK's listed companies. *Management Science Letters*, *11*(1), 117–128. https://doi.org/10.5267/j.msl.2020.8.023

Amin, A. S., Hossain, A. T., Ranasinghe, T., & Zhang, M. (2021). Carbon risk and real earnings management. Rotman School of Management Working Paper, (3794941). https://doi.org/10.2139/ssrn.3794941

Ashraf, N., Comyns, B., Tariq, S., & Chaudhry, H. R. (2020). Carbon performance of firms in developing countries: The role of financial slack, carbon prices and dense network. *Journal of Cleaner Production*, *253*, 119846. https://doi.org/10.1016/j.jclepro.2019.119846

Bajra, U., & Cadez, S. (2018a). The impact of corporate governance quality on earnings management: Evidence from European companies cross-listed in the US. *Australian Accounting Review*, *28*(2), 152–166. https://doi.org/10.1111/auar.12176

Bajra, U., & Čadež, S. (2018b). Audit committees and financial reporting quality: The 8th EU Company Law Directive perspective. *Economic Systems*, *42*(1), 151–163. https://doi.org/10.1016/j.ecosys.2017.03.002

Balachandran, B., & Nguyen, J. H. (2018). Does carbon risk matter in firm dividend policy? Evidence from a quasi-natural experiment in an imputation environment. *Journal of Banking & Finance*, *96*, 249–267. https://doi.org/10.1016/j.jbankfin.2018.09.015

Bhojraj, S., Hribar, P., Picconi, M., & McInnis, J. (2009). Making sense of cents: An examination of firms that marginally miss or beat analyst forecasts. *The Journal of Finance*, *64*(5), 2361–2388. https://doi.org/10.1111/j.1540-6261.2009.01503.x

Bolton, P., & Kacperczyk, M. (2021a). Do investors care about carbon risk? *Journal of Financial Economics*, *142*(2), 517–549. https://doi.org/10.1016/j.jfineco.2021.05.008

Bolton, P., & Kacperczyk, M. (2021b). Global Pricing of Carbon-Transition Risk. NBER Working Paper No. 28510, 1–52.

Cadez, S., & Czerny, A. (2016). Climate change mitigation strategies in carbon-intensive firms. *Journal of Cleaner Production*, 112, 4132–4143. https://doi.org/10.1016/j.jclepro.2015.07.099

Cadez, S., Czerny, A., & Letmathe, P. (2019). Stakeholder pressures and corporate climate change mitigation strategies. *Business Strategy and the Environment*, 28(1), 1–14. https://doi.org/10.1002/bse.2070

Cadez, S., & Guilding, C. (2017). Examining distinct carbon cost structures and climate change abatement strategies in CO2 polluting firm. *Accounting, Auditing & Accountability Journal*, 30(5), 1041–1064. https://doi.org/10.1108/AAAJ-03-2015-2009

Cai, W., & Zhou, X. (2014). On the drivers of eco-innovation：Empirical evidence from China. *Journal of Cleaner Production*, 79, 239–248. https://doi.org/10.1016/j.jclepro.2014.05.035

Chen, X., Cheng, Q., Lo, A. K., & Wang, X. (2015). CEO contractual protection and managerial short-termism. *The Accounting Review*, 90(5), 1871–1906. https://doi.org/10.2308/accr-51033

Chen, S., Deng, C. M., & Chen, H. W. (2020). Financing constraints, internal control and earnings management Strategy. *Southeast Academic*, 4, 147–156.

Chen, G. H., Guan, X., & Wang, J. F. (2018). Can corporate social responsibility inhibit earnings management? –An empirical study based on the regulatory disclosure and voluntary disclosure. *Accounting Research*, 3, 19–26.

Cheng, Q., Lee, J., & Shevlin, T. (2016). Internal governance and real earnings management. *The Accounting Review*, 91(4), 1051–1085. https://doi.org/10.2308/accr-51275

Cheng, B., Xu, Y. P., & Li, X. L. (2018). Public pressure, corporate internationalization and corporate environmental governance. *Statistical Research*, 9, 54–66.

Chen, X., Li, W., Chen, Z., & Huang, J. (2022). Environmental regulation and real earnings management—Evidence from the SO2 emissions trading system in China. *Finance Research Letters*, 46, 102418. https://doi.org/10.1016/j.frl.2021.102418

Chen, Y. L., & Zeng, L. L. (2018). Research on the impact of the implementation of the new Environmental Protection Law on heavily polluting enterprises–An analysis based on listed companies. *Journal of Shandong University (Philosophy and Social Science Edition)*, 229(4), 91–102.

Clarkson, P. M., Li, Y., Pinnuck, M., & Richardson, G. D. (2015). The valuation relevance of greenhouse gas emissions under the European Union carbon emissions trading scheme. *European Accounting Review*, 24(3), 551–580. https://doi.org/10.1080/09638180.2014.927782

Cohen, D. A., & Zarowin, P. (2010). Accrual-based and real earnings management activities around seasoned equity offerings. *Journal of Accounting and Economics*, 50(1), 2–19. https://doi.org/10.1016/j.jacceco.2010.01.002

Cordeiro, J. J., & Tewari, M. (2015). Firm characteristics, industry context, and investor reactions to environmental CSR: A stakeholder theory approach. *Journal of Business Ethics*, 130(4), 833–849. https://doi.org/10.1007/s10551-014-2115-x

Dobler, M., Lajili, K., & Zéghal, D. (2014). Environmental performance, environmental risk and risk management. *Business Strategy and the Environment*, 23(1), 1–17. https://doi.org/10.1002/bse.1754

Fang, H. S., & Jin, Y. N. (2011). Can high quality internal control inhibit earnings management? –An empirical study based on voluntary internal control attestation reports. *Accounting Research*, 8, 53–60. +96.

Gao, X. H. (2022). *Carbon risk and corporate green innovation – A Quasi-natural experiment.* Zhengzhou Institute of Aviation Industry Management.

Görgen, M., Jacob, A., Nerlinger, M., Riordan, R., Rohleder, M., & Wilkens, M. (2020). Carbon risk. Available at SSRN 2930897.

Guo, W. (2014). Political costs and earnings management in the context of financial crisis-evidence from listed companies in china's electricity and heat supply industry. *Green Finance and Accounting*, 3, 52–56.

He, W. F., Chen, L. P., & Liu, W. (2019). Does performance appraisal system affect corporate earnings management behavior. *Nankai Management Review*, 1, 17–30.

Hoffmann, V. H., & Busch, T. (2008). Corporate carbon performance indicators: Carbon intensity, dependency, exposure, and risk. *Journal of Industrial Ecology*, 12(4), 505–520. https://doi.org/10.1111/j.1530-9290.2008.00066.x

Hu, S. L., Xu, G. Y., Dong, W. H., & Dong, Y. C. (2022). Industrial policy, analyst attention and corporate earnings management. *Economic Survey*, 39(4), 118–127. https://doi.org/10.15931/j.cnki.1006-1096.2022.04.011

Huang, R. B., & Zhou, H. F. (2021). A study on the impact of the new Environmental Protection Law on the earnings management of heavy polluters–an empirical test based on the political cost hypothesis. *China Environmental Management*, 2, 63–71.

Huang, S., Roychowdhury, S., & Sletten, E. (2020). Does litigation deter or encourage real earnings management? *The Accounting Review*, 95(3), 251–278. https://doi.org/10.2308/accr-52589

Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305–360. https://doi.org/10.1016/0304-405X(76)90026-X

Kothari, S. P., Mizik, N., & Roychowdhury, S. (2016). Managing for the moment: The role of earnings management via real activities versus accruals in SEO valuation. *The Accounting Review*, 91(2), 559–586. https://doi.org/10.2308/accr-51153

Labatt, S., & White, R. R. (2007). *Carbon finance: The financial implications of climate change* (ed., Vol. 362). Hoboken, New Jersey: John Wiley & Sons.

Lei, G. Y., & Liu, H. L. (2006). Large shareholder control, financing size and degree of earnings manipulation. *Management World*, 1, 129–136. + 172.

Lemma, T. T., Shabestari, M. A., Freedman, M., Lulseged, A., & Mlilo, M. (2020). Corporate carbon risk, voluntary disclosure and debt maturity. *International Journal of Accounting & Information Management*, 28(4), 667–683. https://doi.org/10.1108/IJAIM-06-2019-0064

Li, H., & Li, B. (2019). The threshold effect of environmental regulation on the green transition of the industrial economy in China. *Economic research-Ekonomska Istraživanja*, 32(1), 3134–3149. https://doi.org/10.1080/1331677X.2019.1661001

Li, J. K., Ma, J. J., & Wei, W. (2020). A study of regional differences in energy carbon emission efficiency of eight integrated economic zones in China. *Research in Quantitative Economics and Technology Economics*, 6, 109–129.

Li, W. J. (2007). Economic consequences of government regulation of accounting disclosure—Empirical evidence from the Chinese securities market. *Accounting Research*, 8, 13–21. +95.

Li, Z. F., Dong, Z. Q., & Lian, Y. J. (2011). Accrual earnings management or real earnings management? – A study based on China's 2007 income tax reform. *Management World*, 1, 121–134.

Litterman, B. (2013). What is the right price for carbon emissions. *Regulation*, 36, 38.

Liu, Y. G., Sun, H. Q., & Wang, Y. (2018). Stock option incentives, exercise performance conditions and real earnings management. *Journal of Management Engineering*, 2, 128–136.

Lv, J. Y., & Ai, L. (2021). A study on the impact of carbon risk on corporate share price under social concern. *Coal Economic Research*, 41(11), 14–21.

Ma, C. (2010). A review of research on earnings management motives of listed companies. *Finance and Accounting Newsletter*, 18, 48–50.

Massari, M., Gianfrate, G., & Zanetti, L. (2016). *Corporate valuation: Measuring the value of companies in turbulent posts*. John Wiley & Sons.

Mellado, C., & Saona, P. (2020). Real earnings management and corporate governance: A study of Latin America. *Economic Research-Ekonomska Istraživanja*, 33(1), 2229–2268. https://doi.org/10.1080/1331677X.2019.1691930

Nguyen, J. H. (2018). Carbon risk and firm performance: Evidence from a quasi-natural experiment. *Australian Journal of Management*, 43(1), 65–90. https://doi.org/10.1177/0312896217709328

Nguyen, J. H., & Phan, H. V. (2020). Carbon risk and corporate capital structure. *Journal of Corporate Finance*, 64, 101713. https://doi.org/10.1016/j.jcorpfin.2020.101713

Ning, Y. P. (2004). A study on the definition of earnings management and its significance. *Accounting Research*, 9, 62–66.

Oestreich, A. M., & Tsiakas, I. (2015). Carbon emissions and stock returns: Evidence from the EU Emissions Trading Scheme. *Journal of Banking & Finance*, *58*, 294–308. https://doi.org/10.1016/j.jbankfin.2015.05.005

Ou, L., & Zhao, Z. (2022). Managerial overconfidence, board independence and real earnings management. *Friends of Accounting*, *8*, 72–78.

Phan, D. H. B., Tran, V. T., Ming, T. C., & Le, A. (2022). Carbon risk and corporate investment: A cross-country evidence. *Finance Research Letters*, *46*, 102376. https://doi.org/10.1016/j.frl.2021.102376

Pizzutilo, F., Mariani, M., Caragnano, A., & Zito, M. (2020). Dealing with carbon risk and the cost of debt: Evidence from the European market. *International Journal of Financial Studies*, *8*(4), 61. https://doi.org/10.3390/ijfs8040061

Qian, W., & Schaltegger, S. (2017). Revisiting carbon disclosure and performance: Legitimacy and management views. *The British Accounting Review*, *49*(4), 365–379. https://doi.org/10.1016/j.bar.2017.05.005

Roychowdhury, S. (2006). Earnings management through real activities manipulation. *Journal of Accounting and Economics*, *42*(3), 335–370. https://doi.org/10.1016/j.jacceco.2006.01.002

Shleifer, A., & Vishny, R. W. (1997). A survey of corporate governance. *The Journal of Finance*, *52*(2), 737–783. https://doi.org/10.1111/j.1540-6261.1997.tb04820.x

Tian, G. L., Feng, H., & Yu, Z. B. (2016). A study on the corporate governance role of media in the capital market. *Accounting Research*, *6*, 21–29. +94.

Wang, J. X., & Sun, M. N. (2021). The "Porter's hypothesis puzzle" of green development and governance transition–Evidence based on corporate deleveraging under carbon risk. *Economic Management*, *12*, 41–61.

Wang, X. Y. (2020). Analysis of the impact of carbon risk on corporate debt cost based on media attention—Empirical evidence from A-share listed companies in China. *Technoeconomics*, *4*, 95–102. +131.

Watts, R. L., & Zimmerman, J. L. (1978). Towards a positive theory of the determination of accounting standards. *The Accounting Review*, *53*(1), 112–134.

Wu, Y. Y., Qi, J., Xian, Q., & Chen, J. D. (2021). A study on the carbon emission reduction effect of China's carbon market–based on the synergistic perspective of market mechanism and administrative intervention. *China Industrial Economics*, *8*, 114–132.

Xie, D. R., & Liao, K. (2018). Controlling shareholders' equity pledges and real earnings management of listed companies. *Accounting Research*, *8*, 21–27.

Ye, Q., Li, Z. Q., & Li, G. Q. (2012). Do rich lists affect the quality of corporate accounting information?—An examination based on political cost perspective. *Management World*, *1*, 104–120.

Yu, M. G., Shi, P. N., Zhong, H. J., & Zhang, Q. (2021). Monopoly and firm innovation—Evidence from the implementation of the Anti-Monopoly Law. *Nankai Management Review*, *1*, 159–168. +180 + 204-206.

Yu, M. X. (2021). Corporate social responsibility disclosure and earnings management. Southwest University of Finance and Economics.

Zhou, Z. F., Li, J., Zeng, J., & X, H. (2020). A study on the influence of political and economic stakeholders on corporate carbon performance—An empirical analysis based on chinese listed companies. *Journal of Yunnan University of Finance and Economics*, *4*, 72–88.

Zhou, Z. F., Wen, K., & Zeng, F. X. (2017). Carbon risk, media attention and debt financing cost—Empirical evidence from Chinese A-share listed firms in high carbon industries. *Modern Finance and Economics*, *8*, 16–32.