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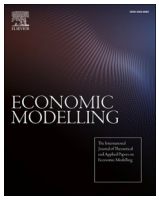

Insuring legitimacy: The role of uncertainty perceptions in shaping corporate insurance demand☆

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ABSTRACT

Geopolitical conflicts, economic shifts, and environmental instabilities heighten uncertainties that challenge corporate legitimacy. These uncertainties foster skepticism among stakeholders, prompting firms to adopt risk management strategies. While much research has focused on macro-level uncertainties, less attention has been given to firm-level perceptions and legitimacy-driven responses. Using data from A-share listed firms in China, this study examines how perceived uncertainties influence the demand for directors' and officers' (D&O) liability insurance. We find that this demand arises not only from litigation risks but also from the need for financial protection. External market conditions and internal governance factors, including control quality and political ties, increase the demand for insurance. Additionally, firms adopt alternative risk management strategies such as financialization, ESG engagement, and digital transformation. This study highlights that as uncertainties evolve, firms will increasingly rely on D&O insurance and complementary strategies to safeguard their legitimacy, offering valuable insights for future research and corporate governance practices.

1. Introduction

Uncertainty plays a significant role in shaping corporate decision-making processes, particularly in contemporary governance. In China, with its dynamic and evolving environment, uncertainties arise from factors such as economic policy volatility, geopolitical tensions, climate change risks, and biodiversity threats. These uncertainties influence a wide range of corporate activities, including investment policies (Gulen and Ion, 2016; Julio and Yook, 2012), financing practices (Brogaard and Detzel, 2015; Çolak et al., 2017), information disclosure strategies (Nagar et al., 2019), merger and acquisition activities (Bonaime et al., 2018), and Environmental, Social, and Governance (ESG) engagement (Peng et al., 2023; Yuan et al., 2022). According to real options theory, firms may delay activities during uncertain times due to risk aversion, whereas strategic growth options theory suggests that risk premiums can incentivize proactive behavior.

Uncertainty also significantly impacts corporate legitimacy, as stakeholders become more cautious and rely heavily on legitimacy evaluations, particularly pragmatic legitimacy(Suddaby et al., 2017; Tost, 2011). Distrustful individuals tend to base their judgments on understandability (cognitive legitimacy) and practical efficacy (pragmatic legitimacy) (Díez-Martín et al., 2021), while emotions such as fear and hope can moderate these perceptions.

Firms exhibit varying degrees of exposure to uncertainty shocks, influenced by differences in industry dynamics, market conditions, regulatory environments, and internal capabilities. For instance, Bloom (2009) highlights how industry-specific factors can lead to diverse responses to economic uncertainty. Consequently, research relying on macro-level uncertainty indices may overlook firm heterogeneity (Baker et al., 2016). To address this limitation, firm-level uncertainty

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perception measurements have been developed, offering a more granular understanding of each firm's unique risk profile and providing better insights into how uncertainty shapes corporate decision-making processes (Chen et al., 2024; Yu et al., 2021).

Firm-level uncertainty perception involves interpreting uncertain economic indicators or market conditions, incorporating nuanced considerations and contextual factors specific to the firm's operations and environment. While it aims to be objective, this perception is inherently subjective, influenced by individual experiences, cognitive biases, and information asymmetry. Upper echelons theory (Hambrick and Mason, 1984) suggests that the characteristics and personal experiences of top management teams (TMTs) significantly shape their strategic choices, including how they perceive and respond to uncertainty. Recent studies support this view, highlighting that TMTs' demographic traits, such as age, tenure, and educational background, are crucial determinants of how firms navigate uncertain environments (Kim et al., 2009). Therefore, firms often base their decisions on their perceptions of uncertainty, especially when addressing complexities related to legitimacy.

In this process, firms assess both the risks posed by uncertain environments and the need to maintain or enhance legitimacy in the eyes of stakeholders. Top management teams, who play a central role in strategic decision-making, are ultimately accountable for the firm's performance and adherence to regulations. Their understanding and interpretation of uncertainty, shaped by their personal traits and experiences, have a direct impact on strategic direction, resource allocation, and the implementation of risk management strategies. As their perception of uncertainty is often more immediate and specific to the firm's unique context, it can drive risk management decisions more effectively than a generalized view of macroeconomic uncertainty (Graham et al., 2015).

Executives, directors, and officers face potential legal and financial liabilities as a consequence of their managerial actions, which intensifies the need for comprehensive risk management solutions. Their concern about potential legal threats, regulatory changes, litigation risks, and stakeholder demands heavily influences how they formulate risk management strategies. In response to these uncertainties, firms may opt for D&O insurance to transfer litigation risk and protect themselves. D&O insurance acts as a vital tool by offering financial protection against personal losses from lawsuits alleging wrongful actions in their corporate roles. This coverage extends not only to legal defense costs but also to settlements and judgments, alleviating the personal financial burden on top management. As a result, D&O insurance empowers executives to pursue strategic initiatives more confidently, without the constant fear of personal liability. Moreover, many D&O insurance policies contain provisions that promote robust governance practices, ensuring companies meet high standards of compliance and ethical conduct (Yuan et al., 2016). Therefore, D&O insurance serves a dual purpose: it safeguards individual executives and enhances the firm's legitimacy during periods of uncertainty. By reducing litigation risks and building stakeholder trust, D&O insurance strengthens the company's governance framework, conveying the firm's dedication to accountability and sound management. This legitimacy-enhancing function becomes particularly important when firms are under intense scrutiny, allowing them to navigate risks more effectively and sustain stability in volatile environments (Adams et al., 2009; Lin et al., 2013).

Using data from A-share Chinese listed firms, this study reveals that firm-level uncertainty perception, based on textual analysis measurement, significantly influences firms' decisions to purchase D&O insurance. Mechanism analysis indicates that this uncertainty-driven insurance demand is primarily motivated by the need to transfer legal liability and create a financial resource buffer. Further analysis highlights significant moderating roles of both external and internal governance mechanisms. Firms located in provinces with higher levels of marketization and those with higher-quality audit processes exhibit weaker uncertainty-driven insurance demand. Moreover, alternative informal risk management mechanisms such as financialization, ESG engagement, and digital transformation are identified as substitutes for D&O insurance. Interestingly, political connections, embeddedness, and state-owned enterprise identity do not dampen firms' insurance demand but rather enhance it. These findings are robust to various sensitivity tests, including shocks to firm-level uncertainty perception, multiple fixed effects, lagged independent variables, and instrumental variable tests.

This research contributes to the literature in three key aspects. First, this paper shifts the focus from the widely studied effects of D&O insurance on corporate governance to the relatively underexplored factors driving the demand for D&O insurance in China. While most existing studies have concentrated on the impact of D&O insurance on governance practices, fewer have examined the determinants of its demand. Limited literature has shown that judicial reforms, which increase legal liability and firm-level tunneling effects that enhance conflicts of shareholder interest, directly elevate D&O insurance demand (Park, 2018; Zou et al., 2008). Furthermore, specific firm or executive characteristics are significantly correlated with this demand (Jia et al., 2019; Xia et al., 2023). Additionally, our study emphasizes firm-level uncertainty perception, while earlier studies typically use macroeconomic uncertainty indices as independent variables (Bonaime et al., 2018; Li and Cheng, 2024; Yu et al., 2021), we highlight the importance of firm-specific heterogeneity in shaping uncertainty exposure. By doing so, our study bridges the literature on uncertainty and firm-level risk management strategies, offering a more delicate understanding of how companies perceive and manage risk.

Second, the study contributes to the understanding of risk management amidst uncertainty, particularly focusing on the interplay of various governance tools within China's unique context. By comparing the effectiveness of diverse risk management mechanisms, such as financialization (Zhao and Su, 2022), the insurance-like effects of corporate social responsibility (Godfrey et al., 2009), and digital transformation (Fang et al., 2023) as potential substitutes for D&O insurance, the research offers insights into the strategies firms in China adopt to mitigate risks. Findings on the influence of political connections, political embeddedness, and state ownership identity (Li and Zhang, 2010) further enhance our understanding of how institutional contexts shape the combination of risk management tools within firms.

The third contribution of this study highlights how uncertainty undermines corporate governance legitimacy and how firms use risk management tools, such as D&O insurance, to maintain it. As the literature shows, uncertainty erodes legitimacy, especially in volatile environments where gaining stakeholder trust is more difficult (Bansal and Clelland, 2004; Christensen, 2016). Our research demonstrates that firms can mitigate legitimacy loss by using tools like D&O insurance and CSR strategies, which help restore stakeholder confidence and align actions with societal expectations (Palazzo and Scherer, 2006). These tools strengthen firms' legitimacy during uncertain times, reducing negative stakeholder reactions.

The following sections are arranged as follows: Section 2 reviews the related literature and formulates research hypotheses, Section 3 introduces the sample and variables as well as the model setting, Section 4 reports the empirical results, and Section 5 provides a conclusion for the entire study.

2. Literature review and research hypothesis

2.1. Uncertainty and corporate decision-making

Uncertainty has been demonstrated to impose significant impacts on corporate behaviors (Crowley et al., 2018; Gulen and Ion, 2016; Julio and Yook, 2012; Wang et al., 2014) influencing a broad spectrum of corporate activities. Existing literature mainly measures macro-level uncertainty in the following three ways. The first calculates financial market volatility, such as standard deviation, beta coefficients, or implied volatility derived from options pricing models, to assess the

degree of fluctuation in asset prices and market movements (Bloom, 2009). The second method quantifies uncertainty by analyzing textual data from news sources, focusing on hedging language, ambiguity, and sentiment. Notable examples include the economic policy uncertainty index (Baker et al. (2016) and the geopolitical risk uncertainty index (Caldara and Iacoviello, 2022). The third approach examines exogenous events that directly impose uncertainty on firm operations, such as political events (Julio and Yook, 2012; Kelly et al., 2016), military alliance (Cao et al., 2023), energy price fluctuations (Stein and Stone, 2013), trade agreement (Handley and Limao, 2015), natural disasters (He et al., 2022), and law revisions (Park, 2018).

These macro-level uncertainties play a significant role in shaping corporate decision-making processes (Bonaime et al., 2018). However, while the real options theory suggests firms delay investments during uncertain times to reduce risk (Wang et al., 2023), the strategic growth options theory presents an alternative view: that uncertainty can create opportunities, motivating proactive corporate strategies such as R&D investments and CSR engagement (Atanassov et al., 2015). Companies facing uncertainty may adjust their strategic direction to manage both external risks and stakeholder perceptions, especially concerning legitimacy (Suddaby et al., 2017; Tost, 2011). Uncertainty significantly affects corporate legitimacy, as stakeholders rely on pragmatic and cognitive legitimacy evaluations (Palazzo and Scherer, 2006). In volatile environments, where stakeholder trust becomes difficult to gain, uncertainty intensifies the risks of legitimacy loss. Firms under heightened uncertainty are more likely to face challenges in maintaining their legitimacy, as stakeholders—investors, customers, and regulators—adopt more cautious and skeptical approaches toward corporate behaviors (Bansal and Clelland, 2004).

Despite the prevailing focus on macro-level uncertainty, firm-specific heterogeneity plays a crucial role in shaping responses to uncertainty (Bloom, 2009). Industry dynamics, regulatory environments, and internal capabilities contribute to the diverse ways firms perceive and respond to uncertainty. Easaw and Grimme (2024) provides robust empirical evidence on the relationship between aggregate and firm-level uncertainty, demonstrating that although aggregate uncertainty is positively correlated with firm-level uncertainty, the strength of this relationship varies significantly. As such, firm-level uncertainty perception measures have been developed to account for these differences, offering more precise insights into how individual firms interpret and manage risks (Chen et al., 2024; Yu et al., 2021). Firm-level uncertainty—captured through textual analysis of corporate reports, MD&A sections, and conference calls (Caldara and Iacoviello, 2022; Li et al., 2024)—is particularly relevant in decision-making processes, as it shapes management's risk aversion, influences resource allocation like labor market behavior (Kovalenko, 2024), and impacts overall organizational performance. Recognizing this, firms increasingly integrate risk management as a strategic investment, employing formal and informal mechanisms such as insurance, political lobbying (Peng et al., 2023), or CSR strategies to mitigate reputational and operational risks (Godfrey et al., 2009).

In China, where geopolitical tensions, regulatory shifts, and economic volatility pose substantial uncertainties (Baker et al., 2016), firms are particularly attuned to adopting risk management tools like D&O insurance in recent years, which provides legal and financial protection for top management (Lin et al., 2013). This trend reflects a broader corporate strategy where legitimacy and risk management are closely intertwined, allowing firms to maintain stable operations and stakeholder confidence during uncertain times (Adams et al., 2009).

2.1.1. D&O insurance demand risk management

D&O insurance provides liability protection for directors and officers against claims related to wrongful acts committed in their managerial roles, safeguarding their personal assets and covering legal costs. This insurance can significantly influence their behavior by reducing personal financial risk, enabling them to engage in riskier but potentially beneficial strategies that they might otherwise avoid due to liability concerns (Lin et al., 2013). Researchers have extensively studied how D&O insurance impacts corporate governance, with findings suggesting that insured executives are more inclined to pursue innovative, high-risk projects (Baker and Griffith, 2007; Chalmers et al., 2002).

However, less attention has been paid to understanding what drives demand for D&O insurance. Various factors contribute to this demand, including changes in the legal landscape, such as the adoption of class-action lawsuits, which heightens perceptions of litigation risks (Park, 2018). Firms facing significant economic policy uncertainty and high litigation risk are also more likely to purchase D&O insurance (Yu et al., 2021). Additionally, cultural and social factors, like the influence of Confucian values, can decrease demand for such insurance, as ethical principles and risk aversion reduce perceived need (Kong et al., 2023). Political connections play a substitutive role in risk management, reducing the need for D&O insurance (Jia et al., 2019), while executive characteristics, such as overconfidence or international experience, can also shape insurance demand (Lai and Tai, 2019; Xia et al., 2023).

Beyond these direct driving factors, firms exhibit varying responses to uncertainty shocks, influenced by industry dynamics, market conditions, and regulatory environments. Bloom (2009) shows that industry-specific factors lead to diverse reactions to uncertainty, while firm-level measurements of uncertainty offer more precise insights than macroeconomic indices (Chen et al., 2024; Yu et al., 2021). Firms often make decisions based on how they perceive uncertainty in their unique context, as this perception directly impacts strategic planning and risk management. The role of top management teams is crucial in navigating uncertainty, as their decisions shape resource allocation and the implementation of risk management strategies. Their ability to interpret firm-specific risks allows for more effective responses compared to relying solely on macroeconomic indicators (Graham et al., 2015). In this context, D&O insurance serves as a vital risk management tool, providing legal protection and alleviating personal financial burdens associated with litigation. This protection empowers executives to pursue strategic initiatives without constant fear of personal liability, promoting greater confidence in decision-making.

2.2. Research hypothesis

D&O insurance acts as a crucial tool for mitigating the personal financial risks faced by directors and officers, particularly in environments characterized by heightened uncertainty. As firms navigate increasingly volatile legal, regulatory, and market dynamics, their need to safeguard leadership through risk management tools becomes more pronounced. According to the precautionary saving theory (Kimball, 1990), firms bolster their safety nets, including insurance coverage, in response to uncertainty. This aligns with the protective behavior model, which posits that firms anticipating legal or regulatory threats will seek insurance to shield executives from personal liabilities. Empirical studies corroborate this view, indicating that firms exposed to greater perceived uncertainty tend to invest in D&O insurance as a way to safeguard their leadership from financial risks (Core, 1997).

Legitimacy theory suggests that firms do not solely aim to mitigate financial risks but also focus on maintaining their legitimacy in the eyes of stakeholders, especially in uncertain environments (Deephouse et al., 2017; Tost, 2011). Legitimacy is critical to securing ongoing support from investors, regulators, and the public, which is increasingly crucial in volatile regulatory contexts like China's current legal landscape. The purchase of D&O insurance can be seen as a signaling mechanism, where firms demonstrate their commitment to good governance, compliance, and risk management (Bitektine and Haack, 2015; Haack et al., 2012). By proactively acquiring insurance to protect directors and officers, firms strengthen their reputation for accountability and transparency, enhancing their legitimacy in the market (Yang et al., 2024).

In this regard, D&O insurance serves not only as a financial safeguard but also as a strategic tool to bolster organizational legitimacy. Firms

facing high uncertainty may adopt D&O insurance to meet societal expectations of responsible corporate behavior and risk management, thereby gaining legitimacy in the eyes of key stakeholders (Deephouse et al., 2017). This is particularly important in markets like China, where rapid legal reforms and heightened public scrutiny demand that firms take visible steps to manage risks and align with evolving regulatory standards. Hence, we propose the following hypotheses.

Hypothesis 1a. A firm's uncertainty perception would prompt the D&O insurance purchase to both mitigate financial risks and enhance organizational legitimacy.

Meanwhile, there is a possibility that an increase in uncertainty perception does not necessarily lead to the purchase of D&O insurance. First, firms may adopt alternative strategies such as implementing strong internal controls and comprehensive risk management strategies to enhance the firm's resilience towards uncertainty (Palermo et al., 2017). In this case, firms may increasingly adopt a risk retention approach, where they opt to manage risks internally rather than transferring them through insurance (Hoyt and Liebenberg, 2011). This approach might be prevalent in firms with robust governance structures. Second, from a legitimacy theory perspective, some firms may not view the purchase of D&O insurance as necessary for maintaining their legitimacy, especially if they have already established a reputation for strong internal governance and risk management practices. These firms may perceive that their governance structures and risk management efforts sufficiently align with stakeholder expectations, thus reducing the need for external signals of compliance. Additionally, firms may perceive the cost of D&O insurance as outweighing its benefits, particularly if they believe the likelihood of significant litigation against directors or officers is minimal.

This perception was more prevalent in China prior to the 2019 Securities Law revision, when the legal environment was less stringent compared to Western standards. The limited perceived risk of legal action against directors and officers influenced firms' decisions regarding the necessity of D&O insurance. Furthermore, the relatively low number of D&O insurance claims cases reinforced the perception that such insurance was not essential, especially during times of resource constraints, contributing to its low adoption rate among listed firms (Li et al., 2023).

Thus, we propose the following competitive hypothesis.

Hypothesis 1b. A firm's uncertainty perception would not prompt the D&O insurance purchase.

Given that litigation risk directly influences the demand for D&O insurance, it is posited that a firm's litigation risk actively influences the relationship between uncertainty perception and insurance demand. When uncertainty in the regulatory or economic environment increases, firms operating in litigious environments or industries (such as pharmaceuticals, financial services, or technology sectors) typically have a heightened awareness of the legal implications of their business decisions. The insurance decision-making model proposed by Kunreuther and Pauly (1985) suggests that firms with higher potential liabilities are more responsive to changes in perceived risk, leading them to seek additional protection through insurance.

The direct and indirect costs associated with litigation can be substantial for firms, particularly those in high-risk sectors. The financial impact encompasses potential settlements, damages, and reputational harm, all of which can influence market performance and shareholder value. Doherty and Smetters (2005) provide insights into how firms assess these potential costs and choose insurance as a financial tool to mitigate these risks. Faced with uncertainty, firms in high-risk sectors might anticipate an increase in litigation, partly due to contractual disputes or increased scrutiny from stakeholders. Classical economic analysis of liability and litigation risk shows that market downturns and economic volatility can intensify the legal challenges that firms encounter, underscoring the critical protective value of insurance. Hence, we propose the following hypotheses.

Hypothesis 2. The demand for D&O insurance, triggered by firm uncertainty perception, is more pronounced in firms with higher litigation risk.

Uncertainty in business environments often increases the risk of unforeseen liabilities, such as litigation or regulatory penalties, which can be particularly burdensome for firms with limited financial flexibility. According to Opler et al. (1999), firms in volatile industries tend to adopt precautionary measures, such as holding larger cash reserves or securing insurance, to buffer against unpredictable financial demands. Similarly, Campello et al. (2010) demonstrate that during periods of heightened uncertainty, firms with less access to external capital markets are more likely to strengthen their liquidity reserves and may also increase their investment in risk management tools like D&O insurance as a strategy to safeguard against potential disruptions (Almeida et al., 2004). For these firms, D&O insurance provides a crucial financial backstop that mitigates the risks associated with unexpected legal challenges. The insurance claims from D&O policies offer a source of financial relief, allowing firms to handle liabilities without compromising their operational stability or exhausting their limited liquidity. Additionally, Han and Qiu (2007) note how financial constraints heighten risk aversion among firms, making them more likely to invest in protective measures such as D&O insurance to manage potential risks associated with their directors' and officers' decisions in uncertain times. In a nutshell, firms with constrained financial resources may lack adequate reserves to cover sudden financial demands, making them more vulnerable to the destabilizing effects of executive-related risks. By prioritizing D&O insurance, these firms effectively utilize it as a strategic tool to enhance their risk management framework, ensuring that they can sustain their operations and protect their assets in a highly uncertain business climate. Hence, we propose the following hypothesis.

Hypothesis 3. The demand for D&O insurance, triggered by firms' uncertainty perception, is more pronounced in firms with constrained financial resources.

Fig. 1 represents the conceptual framework of the current study. outlines how external uncertainties influence corporate behavior and how firms respond through their internal characteristics and strategic approaches.

According to Fig. 1, external uncertainties such as economic policy changes, geopolitical issues, regulatory shifts, climate change, and biodiversity risks directly impact firms, creating an environment of uncertainty. This impact is further moderated by internal factors, including key variables like liability risk and resource reserving, as mentioned earlier. Additionally, a firm's, internal controls, executive attributes (such as political connections and gender diversity within the management team), and regional marketization also influence how firms perceive and respond to these uncertainties. In response to perceived uncertainty, firms must manage the risk of transmitting negative signals to stakeholders, which could undermine their legitimacy. To address this, the diagram introduces legitimacy as a key goal for firms, indicating that protecting their reputation and trust among shareholders is crucial. Consequently, firms adopt specific strategies, including engaging in ESG activities, accelerating digital transformation, and utilizing D&O insurance to transfer liability risks. By implementing these strategies, firms aim to reduce uncertainty, bolster stakeholder confidence, and ultimately support their ongoing operations. The integrated framework depicted in the diagram emphasizes how firms navigate external uncertainties through strategic responses to maintain legitimacy in the eyes of stakeholders.

3. Research design

3.1. Research sample and data sources

Our research sample comprises publicly listed firms in China's A-share market from 2010 to 2020. The D&O insurance data, along with

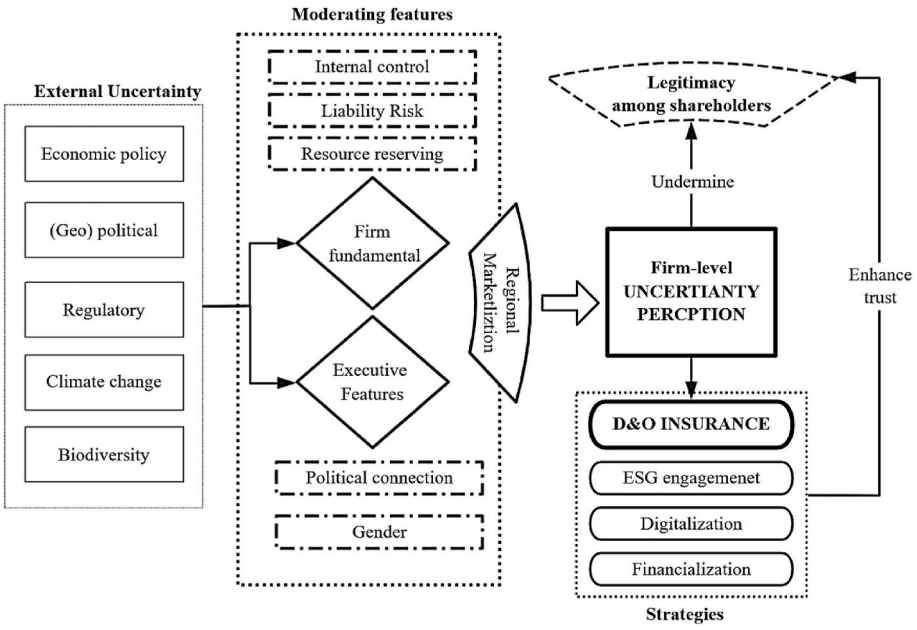


Fig. 1. Conceptual framework.

litigation-related variables and firm-level financial and governance control variables, is sourced from the Chinese Research Data Services Platform (CNRDS) and the China Stock Market & Accounting Research Database (CSMAR). The independent variable, firm-level uncertainty perception, is calculated based on a textual analysis of the annual reports of listed firms from the Shanghai and Shenzhen Stock Exchanges. Following standard procedures, firms in the financial and insurance industries, as well as ST firms, are excluded. After removing observations with missing values, the final sample consists of 25,694 firm-year observations.

3.2. Variables

3.2.1. Uncertainty perception

We construct a firm-level perception of uncertainty as an independent variable through textual analysis of listed firms' annual reports. Specifically, we calculate the frequency of uncertainty-related words throughout the MD&A section in the annual report of each listed firm using a Python program. The uncertainty-related dictionary is detailed in Table A1. Subsequently, we calculate the total number of words in the MD&A section and normalize the frequency of uncertainty-related words according to the length of the section (Benguria and Taylor, 2020; Yu et al., 2021). Finally, the independent variable represents the percentage of relevant words in relation to the total number of words. We further refine this ratio by excluding words and numbers in the text, serving as alternative measures for robustness tests.

3.2.2. D&O insurance demand

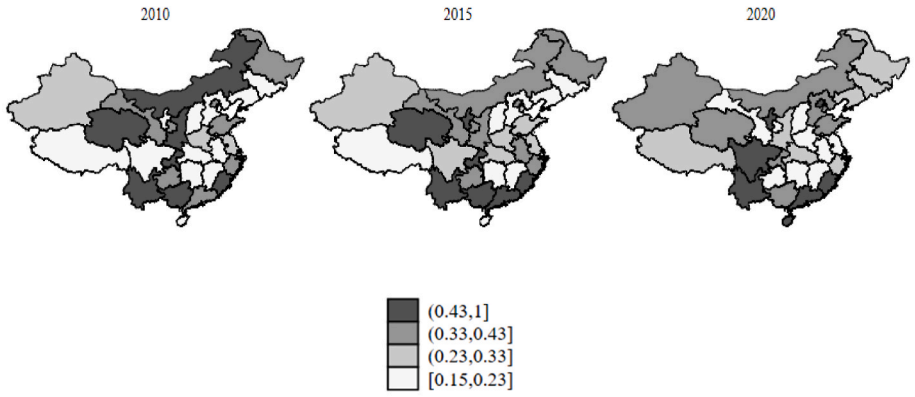
Given that data for D&O insurance premiums and coverage amounts is not mandatory to be disclosed in China, there are very few firms that disclose the data, and many of those that do provide a range rather than a specific amount. Such a small sample may not allow effective empirical analysis. Hence, we use a dummy variable to gauge the impact of firm-level uncertainty perception on D&O insurance demand (Yuan et al., 2016). Specifically, *Doins* is defined as a dummy variable with a value of 1 if a firm purchase D&O insurance and 0 otherwise.

Fig. 2 illustrates the provincial-level trends in China from 2010 to 2020 across two dimensions: D&O insurance market coverage and aggregated average uncertainty perception. The first row shows the expansion of D&O insurance coverage over time, with significant regional disparities. The maps reveal significant provincial-level variations in D&O insurance market coverage from 2010 to 2020. While coastal provinces like Guangdong, Zhejiang, and Jiangsu maintained consistently high coverage throughout the decade, central provinces such as Henan and Hubei showed remarkable growth after 2015, increasing from minimal to moderate coverage levels. Western provinces exhibited divergent patterns - Sichuan and Shaanxi achieved modest coverage by 2020, while Tibet, Qinghai, and Xinjiang remained at negligible levels. Northeastern provinces (Liaoning, Jilin, Heilongjiang) demonstrated slower adoption rates compared to their coastal counterparts, despite similar initial conditions in 2010. Notably, some geographically adjacent provinces developed contrasting patterns, with Hebei showing faster growth than Shanxi, and Fujian outperforming Jiangxi. The data suggests that provincial economic characteristics, rather than simple regional groupings, better explain these differential adoption rates, as evidenced by the exceptional performance

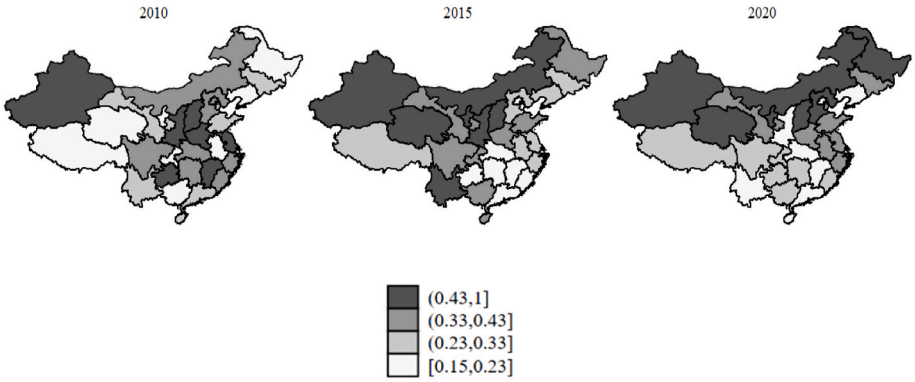
Table 1
Key variable summary statistics.

Variable	N	Mean	Std. Dev.	Min	Max
Doins	26,654	0.046	0.211	0	1
Uncertainty	26,654	0.099	0.105	0	0.535
Uncertainty_N	26,654	0.101	0.106	0	0.483
Uncertainty_NL	26,654	0.101	0.106	0	0.486
Size	26,654	22.025	1.203	19.690	25.644
ROE	26,654	0.070	0.126	−0.685	0.362
Leverage	26,654	0.413	0.209	0.049	0.906
Inde_ratio	26,654	0.374	0.052	0.333	0.571
Dual	26,654	0.284	0.451	0	1
Top1	26,654	0.346	0.148	0.088	0.747
Board	26,654	2.127	0.197	1.099	2.996
Big4	26,654	0.034	0.181	0	1
Oversea_ratio	26,654	0.083	0.125	0	1
Violation	26,654	0.080	0.271	0	1
Litigation	26,654	0.108	0.311	0	1
LnLitigation_amount	26,654	0.600	2.010	0	12.770
Cash_holding	26,654	0.204	0.145	0.019	0.698
Z_score	26,654	6.258	5.744	0.872	36.033
KZ_index	26,654	0.837	2.106	−4.594	5.076

Table 1 presents the summary statistics for major variables, including the number of observations, mean value, standard deviation, maximum, and minimum values.



(1) Provincial D&O insurance market cover



(2) Provincial aggregated uncertainty perception

Fig. 2. Provincial Evolution of D&O Insurance Coverage and average Uncertainty Perception in China (2010–2020).

of Chongqing (western region) matching coastal standards by 2020, while some eastern provinces like Hainan lagged behind their regional peers.

The second-row highlights how firm-level average uncertainty perception varies and evolves across provinces. In 2010, eastern coastal provinces like Shanghai and Guangdong exhibited significantly higher levels of uncertainty perception among listed companies, while western provinces such as Tibet and Qinghai showed the lowest national levels. By 2015, central provinces including Henan and Hubei, along with some western provinces like Sichuan, demonstrated marked increases in perception levels, whereas coastal provinces including Zhejiang experienced declines. The 2020 data reveals that most Yangtze River Delta provinces like Jiangsu and Zhejiang had fallen below their 2010 levels, with northwestern provinces like Xinjiang showing continued increases, and northeastern provinces including Liaoning and Jilin maintaining moderate levels. Notably, Jiangsu displayed a consistent downward trend while neighboring Anhui fluctuated upward, and Beijing and Shanghai followed distinct developmental trajectories that differed significantly from surrounding provinces.

The observed provincial variations in uncertainty perception demonstrate a clear correlation with the development patterns of D&O insurance adoption across China. Provinces with persistently high uncertainty perception (e.g., Guangdong) have consistently maintained strong demand for D&O coverage, while regions showing significant perception increases (e.g., Henan, Xinjiang) subsequently exhibited accelerated D&O market growth. Conversely, provinces where uncertainty perception declined (e.g., Jiangsu, Zhejiang) displayed more mature, stabilized D&O markets by 2020. This spatial-temporal alignment suggests that: (1) rising uncertainty perception serves as a key driver for initial D&O insurance adoption; (2) sustained high perception levels may stimulate ongoing market deepening; while (3) perception declines potentially indicate risk management normalization in developed markets. The exceptional cases - notably Beijing/Shanghai maintaining premium D&O penetration despite perception declines - may reflect unique metropolitan risk profiles where D&O insurance becomes institutionalized regardless of short-term uncertainty fluctuations. These findings underscore the importance of monitoring provincial-level uncertainty dynamics for predicting regional D&O market development trajectories.

3.2.3. *Control variables*

For the set of control variables, several firm-level financial and governance variables reflecting firms' risk, such as firm size (*Size*), financial leverage (*Leverage*), firm profitability (*ROE*) and governance features including independent director ratio(*Inde_ratio*), duality(*Dual*), largest shareholder shareholding ratio(*Top1*), board size(*Board*), big 4 Audit(*Big4*), executive oversea experience ratio(*Oversea_ratio*) are controlled following Jia et al. (2019). The summary statistics is shown in Table 1.

3.3. Model setting

To examine how firm-level uncertainty perception shapes its insurance demand as we proposed in the hypothesis section, we employ a probit model to estimate Equation (1) below:

$$Doins_{i,t} = \alpha_0 + \alpha_1 \text{Uncertainty}_{i,t} + \text{Control}_{i,t} + Year\ FE + Industry\ FE + \varepsilon_{i,t} \quad (1)$$

In the study, we employ a probit model to estimate Equation (1) following Jia et al. (2019) because the dependent variable, $Doins_{i,t}$, is a binary dummy variable indicating whether a firm has purchased D&O insurance. The probit model is particularly suitable for analyzing binary outcomes, as it effectively captures the nonlinear impact of explanatory variables on the probability of an event occurring. Specifically, the probit model assumes a standard normal distribution for the underlying probability and transforms linear predictors into probability values, thereby providing a more accurate estimation of the marginal effects of explanatory variables on the dependent variable.

Furthermore, we control for year and industry fixed effects in the model to account for unobservable heterogeneity across time and industry dimensions following Jia et al. (2019). Year fixed effects help control for the influence of macroeconomic conditions, policy changes, and other time-specific trends on the overall demand for D&O insurance. Industry fixed effects, on the other hand, capture structural differences across industries.

4. Empirical results

4.1. Baseline results

4.1.1. Uncertainty perception and D&O insurance demand

Table 2 presents the regression results exploring the relationship between uncertainty, firm characteristics, and the demand for D&O insurance (*Doins*). Various measures of uncertainty, including overall *Uncertainty*, *Uncertainty_N* (Uncertainty related words eliminating numerical characters), and *Uncertainty_NL* (Uncertainty related words eliminating numerical characters and letters), show positive and significant effects on D&O insurance demand. Specifically, the coefficient for Uncertainty in column (1) is 0.342 ($p < 0.01$), while in column (2), the coefficient of Uncertainty rises to 0.439 ($p < 0.01$), reflecting a robust relationship. In contrast, higher return on equity (ROE) is negatively associated with insurance demand, as firms with greater profitability may perceive less need for such protection. Leverage also shows a positive correlation, suggesting that firms with higher debt levels are more inclined to seek insurance (0.540, $p < 0.01$). Additional governance variables, including the independent director ratio (*Inde_ratio*), the presence of a dual CEO-chair role (*Dual*), and top shareholder concentration (*Top1*), further highlight the influence of internal corporate structure. For example, firms with a higher independent director ratio are more likely to demand D&O insurance (0.746, $p < 0.05$), while those with a dual CEO-chair setup or significant shareholder concentration show lower demand. The models also control audit characteristics, with Big4 auditors significantly increasing the likelihood of D&O insurance demand. Year and industry fixed effects are included in all regressions to control for unobservable factors, and robust standard errors are used. Hence, we could portrait typical firms that purchase D&O insurance in China as larger firms with more international and independent

Table 2
Uncertainty perception and D&O insurance demand.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Doins	Doins	Doins	Doins	Doins	Doins
Uncertainty	0.342***	0.439***				
	(2.76)	(3.43)				
Uncertainty_N			0.354***	0.448***		
			(2.86)	(3.50)		
Uncertainty_NL					0.354***	0.447***
					(2.87)	(3.50)
Size		0.097***		0.097***		0.097***
		(6.20)		(6.21)		(6.21)
ROE		−0.206*		−0.206*		−0.206*
		(-1.85)		(-1.85)		(-1.85)
Leverage		0.540***		0.539***		0.539***
		(5.86)		(5.85)		(5.85)
Inde_ratio		0.746**		0.745**		0.745**
		(2.57)		(2.57)		(2.57)
Dual		−0.319***		−0.319***		−0.319***
		(-8.53)		(-8.53)		(-8.53)
Top1		−0.573***		−0.573***		−0.573***
		(-5.76)		(-5.76)		(-5.76)
Board		0.069		0.069		0.069
		(0.83)		(0.83)		(0.83)
Big4		0.606***		0.605***		0.605***
		(10.49)		(10.48)		(10.48)
Oversea_ratio		0.773***		0.773***		0.773***
		(7.48)		(7.48)		(7.48)
Constant	−1.349***	−3.912***	−1.351***	−3.918***	−1.351***	−3.917***
	(-9.22)	(-10.06)	(-9.24)	(-10.07)	(-9.24)	(-10.07)
Observations	25,694	25,694	25,694	25,694	25,694	25,694
Pseudo R2	0.0675	0.120	0.0676	0.120	0.0676	0.120
Year FE	Y	Y	Y	Y	Y	Y
Ind FE	Y	Y	Y	Y	Y	Y

Table 2 presents the results for the impact of uncertainty perception on D&O insurance demand using probit regression. D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. Definitions of variables are shown in Table A3. Yearly and industry fixed effects are controlled to avoid the confounding effects from unobservable factors. Robust standard errors are used in the regression. ***, **, and * indicate significant levels of 1 %, 5 %, and 10 %, respectively.

executives, high-quality audits, higher leverage ratios, but lower profitability and decentralized decision-making.

We refer Yue et al. (2024) applying word2vec to analyze the Management Discussion and Analysis (MD&A) sections from Chinese public firms. The word2vec model is employed to capture the semantic meaning of words by placing similar words close together in a high-dimensional vector space. We use our original word list (Table A.1) as seed words and then use word2vec to identify synonyms for these seed words. The synonyms help expand the word list, which is then used to measure the strength of uncertainty in firms' MD&A sections. The importance of each word is further refined using the TF-IDF (Term Frequency-Inverse Document Frequency) method, which adjusts the weight of words based on their frequency in the document relative to their presence in the overall corpus. Then, we generate a revised measurement of firms' uncertainty perception by aggregating the scores of uncertainty-related words found in the MD&A sections. The results based on the revised uncertainty measure, as developed through the word2vec textual analysis process, still show strong significance.

4.1.2. Uncertainty, organization legitimacy and D&O insurance

In response to uncertainty, firms often adopt various risk management strategies to protect their organizational legitimacy and strengthen their reputation among stakeholders. To further explore this relationship and considering the difficulty of directly measuring legitimacy, we examine the impact of legitimacy-related characteristics, such as anti-corruption standards and gender diversity in management, on the demand for D&O insurance. These factors are critical in assessing whether firms with stronger legitimacy mechanisms are less reliant on external risk management tools like insurance when facing uncertainty.

Table 3 shows the relationship between uncertainty, organizational legitimacy indicators (such as anti-corruption standards and gender diversity among managers), and the demand for D&O insurance. The interaction terms between uncertainty and anti-corruption standards (−0.686, $p < 0.05$) are negative and significant, suggesting that firms with robust anti-corruption frameworks may rely less on external risk management tool as a hedge against uncertainty because such practices inherently bolster their legitimacy and lower the perception of risk from stakeholders.

Table 3
Legitimacy related features, uncertainty perception and D&O insurance demand.

	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Uncertain × Anti-corruption	−0.686**		
	(-1.98)		
Uncertain × Female manager		−2.440**	
		(-2.25)	
Uncertain × Female director			−2.033*
			(-1.92)
Uncertain	0.479***	0.768***	0.621***
	(3.59)	(3.38)	(3.33)
Anti-corruption	0.441***		
	(8.61)		
Female manager		−0.441***	
		(-2.61)	
Female director			−0.207
			(-1.35)
Constant	−1.354***	−1.257***	−1.311***
	(-9.25)	(-8.45)	(-8.89)
Observations	25,694	25,694	25,694
Pseudo R^2	0.134	0.120	0.149
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 3 presents the regression results examining the effect of uncertainty and various legitimacy related moderating factors on D&O insurance demand (Doins). D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. The interaction terms, including uncertainty with anti-corruption, female managers, and female directors, highlight the organizational legitimacy's moderating effects on the relationship between uncertainty and insurance demand. Definitions of variables are provided in Appendix A. Yearly and industry fixed effects are included to control for unobservable factors, and robust standard errors are employed in the regression. ***, **, and * indicate significant levels of 1 %, 5 %, and 10 %, respectively.

The results in column (2) and (3) is consistent, the coefficient for the interactive term is −2.440 ($p < 0.01$) and −2.033 ($p < 0.1$) respectively, indicating that a higher proportion of female representation within the firm further reduces the likelihood of D&O insurance purchases under uncertain conditions. These results align with existing literature, such as Hillman et al. (2007) and Bear et al. (2010), which argue that firms with more female managers tend to enhance their legitimacy through improved governance and corporate responsibility, reducing the perceived need for external risk management tools like D&O insurance.

To sum up, the coefficient for uncertainty is positive and highly significant in Table 3, indicating that firms generally tend to increase their D&O insurance demand in response to uncertainty. However, this demand is mitigated when firms have stronger organizational legitimacy.

4.1.3. Mechanism analysis: litigation risk

The classical insurance demand theory posits that both ex-ante adverse selection and ex-post moral hazard motivate insurance purchases. Given that litigation risk for directors' and officers' misconduct is the primary risk covered by liability insurance, prior studies have shown that concerns about litigation risk are a major driver of firms' decisions to purchase D&O insurance (Park, 2018; Zou et al., 2008). Adverse selection occurs when firms with a higher risk of experiencing losses are more likely to purchase insurance. After recognizing their heightened risk profiles, firms have a stronger incentive to secure insurance coverage to protect themselves against potential financial liabilities. Meanwhile, some research also suggests that D&O insurance is part of firms' overall strategic risk management approach. Insurance coverage can provide a competitive advantage by enhancing the firm's ability to withstand unexpected events and thus be more capable of innovation (Wang et al., 2020), thereby enhancing their competitive position. Additionally, D&Os are usually conservative and risk-averse when fulfilling their duty; therefore, D&O insurance is sometimes utilized to attract risk-averse executives (Wang et al., 2020), and such insurance coverage is perceived as part of the compensation package (C. Lin et al., 2011).

Hence, we intend to test whether firms D&O insurance under uncertainty is driven by liability transferring adverse selection motive. Firms' violation records (*Violation*), litigation history (*Litigation*) as well as the monetary amount related to litigation (*LnLiti_amount*) are employed as measurements for firms' litigation risk. Table 4 reports the regression results analyzing the effects of uncertainty, violation, litigation, and litigation amount on D&O insurance demand (Doins). In column (1), Uncertainty × Violation is positive and significant (0.887, $p < 0.05$), indicating that uncertainty combined with violations increases D&O insurance demand, with Uncertainty also significant (0.333, $p < 0.05$). In Model (2), Uncertainty × Litigation shows a positive and significant effect (0.680, $p < 0.05$), suggesting that litigation under uncertainty similarly raises demand, while both Uncertainty (0.303, $p < 0.05$) and Litigation (0.122, $p < 0.05$) are significant. Model (3) finds a highly significant effect for Uncertainty × LnLitigation_amount (0.120, $p < 0.01$), indicating higher litigation related amounts under uncertainty further increase D&O demand. These models show that uncertainty consistently drives higher D&O insurance demand.

4.1.4. Mechanism analysis: financial resources reserve

According to Goodell et al. (2021), when there is greater uncertainty, measured by ex post volatility under rational expectations, firms will hold more cash, which is consistent with the precautionary saving hypothesis. In our research setting, we assume that higher uncertainty may

Table 4
Channel analysis: litigation risk.

	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Uncertainty × Violation	0.887**		
	(2.29)		
Uncertainty × Litigation		0.680**	
		(2.07)	
Uncertainty × LnLitigation_amount			0.120***
			(2.61)
Uncertainty	0.333**	0.303**	0.301**
	(2.43)	(2.13)	(2.17)
Violation	−0.014		
	(-0.20)		
Litigation		0.122**	
		(2.15)	
LnLitigation_amount			0.005
			(0.60)
Constant	−3.951***	−4.064***	−3.981***
	(-10.14)	(-10.49)	(-10.24)
Observations	25,694	25,694	25,693
Pseudo R^2	0.121	0.123	0.121
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 4 presents the results of tests determining whether perceptions of uncertainty trigger demand for D&O insurance by increasing the threat of litigation liability. D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. Definitions of variables can be found in Table A3. Year and industry fixed effects are controlled to mitigate the confounding effects of unobserved variables. Robust standard errors are used in the regression. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 5
Channel analysis: financial resources reserve.

	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Uncertainty × Cash_holding	−1.734*		
	(-1.80)		
Uncertainty × Z_score		−0.088***	
		(-3.10)	
Uncertainty × KZ_index			0.153**
			(2.36)
Uncertainty	0.748***	0.886***	0.224
	(3.44)	(4.70)	(1.44)
Cash_holding	−0.007		
	(-0.04)		
Z_score		0.014***	
		(3.04)	
KZ_index			−0.001
			(-0.06)
Constant	−3.869***	−4.066***	−3.992***
	(-9.83)	(-10.23)	(-10.24)
Observations	25,694	25,694	25,694
Pseudo R^2	0.120	0.121	0.121
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 5 presents the results of tests determining whether perceptions of uncertainty trigger demand for D&O insurance by increasing firms' need for reserving financial resources. D&O insurance demand (Doins) functions as dependent variable. Definitions of variables can be found in Table A3. T-values are reported in parentheses. Year and industry fixed effects are controlled to mitigate confounding effects from unobserved variables. Robust standard errors are used in the regression. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

cause firms to be more cautious by reserving financial resources in advance to cover potential liabilities that result in costs. Hence, another possible mechanism through which uncertainty drives D&O insurance might be by making firms more eager to secure financial resources during litigation. If that is the case, such uncertainty-driven insurance demand might be more pronounced in firms with limited financial resources.

Uncertainty can significantly impact firms' behaviour, especially under financial constraints. Firms facing greater uncertainty are more likely to insure against potential losses to avoid scenarios that could lead to financial distress. Campello et al. (2010) suggest that firms with financial constraints often face heightened barriers to external financing, making them more vulnerable to unexpected financial disturbances. Liability insurance serves as a critical risk management tool by covering potential liabilities, thus preserving the limited financial resources essential for ongoing operations.

The cash holding ratio (*Cash_holding*), financial distress (*Z_score*), and the *KZ index* are utilized to measure the degree of firms' financial resources in three aspects. In column (1), the interaction between *Uncertainty* and *Cash Holding* is negative and marginally significant (−1.734, $p < 0.10$), suggesting that higher cash reserves reduce D&O insurance demand under uncertainty. Column (2) shows that Uncertainty × Z-Score is significantly negative (−0.088, $p < 0.01$). Considering that *Z_score* is a reverse indicator for financial distress, these results indicate that firms with less financial distress demand less D&O insurance. In contrast, Column (3) finds a positive and significant interaction between Uncertainty and KZ Index (0.153, $p < 0.05$), implying that financially constrained firms (higher KZ index) increase their demand for D&O insurance under uncertainty. In summary, these results confirm that the uncertainty-driven demand for D&O insurance is more pronounced in firms with fewer financial resources. This suggests that uncertainty perception enhances firms' liquidity concerns, leading them to seek D&O insurance as a means of mitigating potential legal and regulatory risks, ensuring management stability, and preserving critical financial flexibility in their operational and strategic decision-making.

4.2. Moderating analysis

4.2.1. External and internal governance

In this section, we explore the moderating role of the governance effects from both external market environment and internal governance quality. Given the varying levels of market development across Chinese provinces, it is crucial to assess whether the perceived uncertainty associated with purchasing D&O insurance differs based on the marketization level of the province in which a firm operates. In highly marketized environments, firms may perceive less uncertainty since they often benefit from greater policy transparency and clearer regulatory frameworks. Even if firms still perceive high uncertainty, there are more options for risk management within regions with a more marketized environment, including risk transfer such as strategic CSR engagement's insurance-like effects, advanced statistical ex-ante risk assessment, stress testing, and portfolio diversification.

Hence, we use the Marketization Index for China at the provincial level developed by Fan and Wang (2018), which encompasses several dimensions of market development. We selected the overall Marketization Index (*Marketization*), the regional Non-SOE sector development (*Non-state*), and the legal institution environment (*Legislation*) as moderating factors for external governance in our analysis.

The results reported in Table 6 show that the coefficient for the variable of interest *Uncertainty*× *Marketization* is significantly negative at 1 % level, suggesting that the firms located in more marketized regions are less likely to purchase D&O insurance under uncertainty perception. Similarly, column (2) shows that Uncertainty × Legislation is also negative and significant (−0.120, $p < 0.01$), suggesting that stronger legislation lowers the need for D&O insurance when facing uncertainty. Column (3) reveals a significant negative effect for Uncertainty × Non-state (−0.200, $p < 0.01$), indicating that firms located in regions with more developed non-state economy have a reduced D&O insurance demand under uncertainty. This result implies that the

Table 6
Moderating analysis for external governance: regional marketization.

	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Uncertainty × Marketization	−0.255***		
	(-3.18)		
Uncertainty × Legislation		−0.120***	
		(-2.81)	
Uncertainty × Non_state			−0.200***
			(-2.58)
Uncertainty	2.907***	1.719***	2.646***
	(3.75)	(3.70)	(3.09)
Marketization	0.108***		
	(7.53)		
Legislation		0.058***	
		(7.43)	
Non_state			0.071***
			(5.03)
Constant	−4.934***	−4.370***	−4.745***
	(-11.72)	(-10.92)	(-11.06)
Observations	25,694	25,694	25,694
Pseudo R^2	0.126	0.125	0.123
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 6 presents an analysis of the moderating effects of the external governance environment, which includes provincial marketization, the legal environment, regional development of the non-state-owned economy. D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. Definitions of variables are available in Table A3. Both year and industry fixed effects are controlled to mitigate confounding effects from unobserved variables. Robust standard errors are used in the regression. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

presence of a well-established non-state economy in a given region may buffer the impact of uncertainty on firms' risk management strategies. Specifically, firms operating in these regions may have access to alternative mechanisms or greater market resilience, which reduces their reliance on D&O insurance as a protective measure against potential risks. In a nutshell, our finding highlights the importance of regional economic development in shaping how firms perceive and respond to external uncertainties, particularly in terms of insurance purchasing decisions.

Additionally, from the perspective of internal governance, the quality of internal controls is fundamental in determining the risk faced by a firm. High audit quality, for example, typically indicates more accurate financial reporting and better compliance with regulatory standards, thereby reducing the likelihood of financial misstatements or other irregularities that could lead to legal actions. According to S. Lin et al. (2011), firms with robust audit processes have fewer instances of financial discrepancies, which directly correlates with a decreased risk of litigation against directors and officers. Furthermore, Doyle et al. (2007) corroborate this assertion by demonstrating that firms with strong internal control systems experience significantly fewer compliance failures and legal disputes.

Panel A in Table 7 presents the results of the regression analysis examining the relationship between audit quality and the demand for D&O insurance under uncertainty. The findings reveal that higher audit quality, reflected in better internal controls, is associated with a significant reduction in the demand for D&O insurance when firms face uncertainty.

In column (1), the interaction between uncertainty and Big4 auditors shows a significant negative effect on D&O insurance demand (−1.398, $p < 0.01$), suggesting that companies audited by Big4 firms, which typically provide higher audit quality, require less D&O insurance during uncertain times. Similarly, in column (2), the interaction between uncertainty and the frequency of audit committee meetings is negative and significant (−0.188, $p < 0.01$), indicating that companies with more active audit committees also demand less D&O insurance under uncertainty.

Table 7
Moderating analysis for internal governance: audit quality.

Panel A: Audit quality	(1)	(2)	(3)	(4)
VARIABLES	Doins	Doins	Doins	Doins
Uncertain × Big4	−1.492***			
	(-2.84)			
Uncertain × Freq_Audit_committte		−0.204***		
		(-3.77)		
Uncertain × Non_approve_opinion			14.127**	
			(2.25)	
Uncertain × Audit expense				2.714**
				(2.19)
Uncertain	0.521***	0.771***	0.436***	0.219
	(4.00)	(5.30)	(3.45)	(1.32)
Big4	0.748***			
	(9.61)			
Freq_Audit_committte		0.043***		
		(5.81)		
Non_approve_opinion			−3.685**	
			(-2.41)	
Audit expense				0.462**
				(2.46)
Constant	−3.953***	−4.630***	−4.579***	−3.799***
	(-10.15)	(-11.87)	(-11.82)	(-8.86)
Observations	25,694	25,694	25,694	25,694
R-squared	0.121	0.112	0.110	0.111
Control	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Ind FE	Y	Y	Y	Y

Panel B: Internal control	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Uncertain × Deficiency_standard	−0.743**		
	(-2.14)		
Uncertain × Num_deficiency		0.042	
		(1.06)	
Uncertain × Unresolved_deficiency			1.431**
			(2.13)
Uncertain	1.052***	0.432***	0.321
	(3.30)	(3.42)	(1.28)
Deficiency_standard	0.354***		
	(5.48)		
Num deficiency		−0.020	
		(-1.17)	
Unresolved deficiency			−0.206
			(-1.55)
Constant	−4.548***	−4.596***	−3.342***
	(-11.66)	(-11.83)	(-4.40)
Observations	25,694	25,694	6265
Pseudo R^2	0.113	0.110	0.133
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 7 presents the results of tests on the moderating effects of the internal governance environment, specifically on audit quality. D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. Definitions of variables are provided in Table A3. Both year and industry fixed effects are controlled to mitigate potential confounding effects arising from unobserved variables. Robust standard errors are employed in the regression analysis. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Column (3) shows that when uncertainty interacts with a non-approval audit opinion, the demand for D&O insurance significantly increases (14.69, $p < 0.05$). This result implies that when potential risks are identified during the audit process, firms facing uncertainty are more likely to seek additional protection through insurance. Similarly, column (4) demonstrates that higher audit expenses, when combined with uncertainty, lead to a higher demand for D&O insurance (3.979, $p < 0.01$). This suggests that firms with greater audit expenditures, possibly

due to identifying more risks or complexities in the audit process, increase their reliance on insurance as a risk management tool.

Panel B examines the impact of internal control deficiencies on the demand for D&O insurance under conditions of uncertainty. The results show that companies with established standards for managing internal control deficiencies experience a lower demand for D&O insurance when facing uncertainty. Specifically, the interaction between uncertainty and the existence of internal control deficiency management standards is negative and significant (−0.743, $p < 0.05$), indicating that firms with such standards have stronger internal control systems, thus reducing the perceived need for insurance as a risk management tool. The overall number of internal control deficiencies, however, does not significantly affect the demand for D&O insurance.

Notably, the presence of unresolved internal control deficiencies has a significant positive impact on D&O insurance demand under uncertainty. In column (3), the interaction between unresolved deficiencies and uncertainty is positive and significant (1.431, $p < 0.05$), indicating that unresolved issues heighten risk perception, leading firms to seek additional protection through insurance. This result underscores the importance of resolving internal control issues in reducing risk exposure and reliance on external insurance during uncertain times.

4.3. Further analysis: alternative risk source and management mechanisms

As Fig. 1 explores the diverse sources of risk and illustrates how different types of uncertainty influence firms' risk management strategies, these external uncertainty factors, such as geopolitical risks, biodiversity concerns, and economic policy changes, act as key drivers in prompting firms to adopt risk mitigation measures. In this context, Table 8 further examines the relationship between various sources of external uncertainty and the demand for D&O liability insurance (Doins) across multiple model specifications. The results substantiate the significant influence of these external uncertainties on the demand for D&O insurance, highlighting how different uncertainty sources, such as geopolitics, biodiversity, and economic policy risks, encourage firms to secure additional insurance coverage. For example, geopolitical uncertainty, as analyzed using a sub-indicator word list from Yue et al. (2024) and applied to textual analysis of management discussions, shows a positive and significant relationship with D&O insurance demand. This is demonstrated by a coefficient of 0.489 (t-statistic = 5.21) in Column (1) and 0.292 (t-statistic = 2.96) in Model (2). Similarly, biodiversity risk exposure, derived from He et al. (2024), also exerts a strong effect, with coefficients of 1.621 (t-statistic = 4.48) in Column (3) and 1.584 (t-statistic = 3.85) in Column (4), indicating that firms facing heightened environmental uncertainties tend to increase their D&O insurance purchases. Economic policy uncertainty, which is also based on textual analysis of corporate annual reports as indicated in Li et al. (2024), shows a significant but somewhat variable relationship, reinforcing the notion that external factors like regulatory changes have a tangible impact on firms' risk management decisions. These findings are consistent with the framework shown in Fig. 1, illustrating the direct and indirect roles these uncertainties play in shaping firms' strategic responses, including their approach to liability risk management through D&O insurance. The statistical significance of the coefficients across various firm characteristics and governance variables further supports the robustness of these results, confirming the broader impact of uncertainty on corporate behavior.

There are various risk management strategies available, and a firm can select the most appropriate strategy based on its specific risk exposure. One notable area of interest is the exploration of alternatives to D&O insurance, which can illuminate the essential role this insurance plays in managing risk. The literature extensively discusses how D&O insurance significantly impacts corporate governance. For example, it provides direct financial support in the event of litigation, and plays a crucial role in enhancing daily corporate governance by improving monitoring mechanisms, which, in turn, influence the quality of firm financial reporting—evidenced by a reduction in financial restatements (Yuan et al., 2016). Moreover, Laux and Laux (2009) highlight that D&O insurance may reduce the likelihood of conservative accounting practices due to the protective layer it offers to executives against potential litigation. We hypothesize that the essence of D&O insurance's risk management effects might include providing financial resource reserves during litigation as well as reducing information asymmetry and enhancing compliance with legal and regulatory frameworks. Consequently, we test the interplay between firm-level digital transformation, financialization, and ESG engagement on the demand for D&O insurance by examining whether these elements perform substitutive roles. Research by Core (1997) suggests that as firms become more financially resourceful, their dependence on traditional insurance mechanisms decreases. Similarly, the integration of robust ESG practices could potentially mitigate governance-related risks, thus reducing the reliance on D&O insurance (Cheng et al., 2014). The observations by Cheng and Masron (2023) prompt a closer examination of how modern corporate strategies and digital advancements impact traditional risk management approaches, particularly in the context of insurance and corporate governance.

The roles of firm-level digital transformation, financialization, and ESG engagement are examined to determine their substitutive impact on the demand for D&O insurance. We introduce interactions between uncertainty and the factors of digitalization, financialization, and ESG; the regression results are presented in Table 9. The coefficient of

Table 8
Additional uncertainty and firm D&O insurance demand.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Doins	Doins	Doins	Doins	Doins	Doins
Geopolitics	0.489***	0.292***				
	(5.21)	(2.96)				
Biodiversity			1.621***	1.584***		
			(4.48)	(3.85)		
Economic policy					0.312**	0.165
					(2.22)	(1.12)
Constant	−1.281***	−3.783***	−1.338***	−4.054***	−1.324***	−3.782***
	(-8.47)	(-9.29)	(-9.12)	(-10.26)	(-9.11)	(-9.75)
Observations	23,095	23,095	24,794	24,794	25,694	25,694
Pseudo R^2	0.0715	0.122	0.0711	0.124	0.0673	0.119
Control	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Ind FE	Y	Y	Y	Y	Y	Y

Table 8 presents the results of tests on the multiple sources of uncertainty on D&O insurance demand. D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. Both year and industry fixed effects are controlled to mitigate potential confounding effects arising from unobserved variables. Robust standard errors are employed in the regression analysis. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 9
Alternative risk management method: digitalization, financialization, and ESG.

	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Uncertainty × Digitalization	−2.607*		
	(-1.81)		
Uncertainty × Financialization		−3.710***	
		(-2.95)	
Uncertainty × ESG			−0.024*
			(-1.88)
Uncertainty	0.554***	0.600***	2.145**
	(3.82)	(4.20)	(2.34)
Digitalization	−0.007		
	(-0.04)		
Financialization		1.026***	
		(4.95)	
ESG			0.007***
			(2.88)
Constant	−3.967***	−3.962***	−4.220***
	(-10.16)	(-10.16)	(-10.37)
Observations	25,694	25,694	25,694
Pseudo R^2	0.120	0.122	0.121
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 9 presents results assessing whether other risk management strategies, such as digitalization, financialization, and ESG, could serve as substitutes for D&O insurance. D&O insurance demand (Doins) functions as dependent variable. Definitions of the variables are detailed in Table A3. T-values are presented in parentheses. Both year and industry fixed effects are included to control potential confounding from unobserved variables. Robust standard errors are employed in the regression analysis. ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively.

Uncertainty×*Digitalization* is negative and marginally significant (−2.607, $p < 0.10$), indicating that higher levels of digitalization reduce the demand for D&O insurance when facing uncertainty. Column (2) shows a strongly negative and significant interaction for Uncertainty × Financialization (−3.710, $p < 0.01$), suggesting that firms with higher financialization demand less for D&O insurance under uncertainty. Consistent with (Su et al., 2024), are also less inclined to pursue D&O insurance. Effective ESG practices can boost a company's reputation, enhance trust and loyalty among stakeholders, and thereby reduce the likelihood of reputational damage and related litigation. This also fosters a favorable regulatory environment and improved labor relations, ultimately reducing legal challenges against directors and officers. Furthermore, many ESG initiatives comply strictly with legal and regulatory frameworks, thus diminishing the risk of legal breaches and subsequent claims (Godfrey et al., 2009).The coefficient of *Uncertainty*×*ESG* is significantly negative at 10 % level, suggesting that firm with higher ESG rating have a lower demand for D&O insurance under uncertainty. Therefore, ESG engagement not only diminishes reliance on traditional insurance solutions but also underscores its substitutive role in relation to D&O insurance, even amid increased uncertainty.

Another strand of literature suggests that in China's institutional background, alternative mechanisms such as social connections play a major role. Haveman et al. (2017)'s study find that firms reduce uncertainty by developing relationships with state bureaucrats and power institutions during China's economic transition. This helps firms learn how state bureaucracies operate and gains trust from bureaucrats. They also found that firms with political connections tend to suffer less from litigation; consequently, these firms have a lower demand for D&O insurance. Meanwhile, Firms with political connections might be more risk-averse, primarily due to the heightened political pressure and regulatory scrutiny they face. These firms operate under the watchful eye of regulators and the public, making them cautious in their business decisions to maintain a favorable image and avoid conflicts with political expectations. According to Faccio (2006), politically connected firms are often subject to more stringent regulatory oversight, which compels them to adopt conservative strategies to mitigate potential legal and reputational risks. Moreover, Goldman et al. (2013) highlight that these firms, aware of the volatility in political environments, may prioritize long-term stability and alignment with current and anticipated government policies over pursuing higher-risk, higher-return opportunities.

Hence, it is meaningful to test whether political connections (or embeddedness) also mitigate uncertainty in general, thus reducing firms' D&O insurance demand. Considering that political connections are closely related to firms' ownership properties, the initial test was conducted by introducing the interaction between *Uncertainty* and *SOE*. In column (1), Uncertainty × SOE is positive and significant (0.714, $p < 0.01$), showing that state-owned enterprises are more likely to increase their D&O insurance demand under uncertainty. SOEs are generally more risk-averse due to political interference, public accountability, and complex governance structures. Consequently, SOEs have a higher demand for D&O insurance to mitigate personal financial risks associated with managerial decisions and actions, providing indemnification against lawsuits alleging wrongful acts or negligence. Subsequently, we replicated the above process by introducing the interaction between *Uncertainty* and *Political Connection* (referring to whether the firm has executives as deputies at the national level NPC or PCC) (Jia et al., 2019), as well as political embeddedness, measured by the *Party_ratio* (referring to the ratio of executives with CCP affiliation) and the *Cross_position* (referring to whether the chairman of the board also serves as the chairman of the company's party committee).

According to the results tabulated in Table 10, the coefficient of *Uncertainty* × *Political_connection* is significantly positive (0.735, $p < 0.01$), suggesting that political connection not only did not weaken the D&O insurance demand, but rather, uncertainty-triggered D&O insurance demand is more pronounced in firms with political connections.

Table 10
Further analysis: SOE, political connection and executive social connection.

	(1)	(2)	(3)	(4)
VARIABLES	Doins	Doins	Doins	Doins
Uncertainty × SOE	0.714***			
	(2.66)			
Uncertainty × Political_connection		0.735***		
		(2.64)		
Uncertainty × Party_ratio			1.248**	
			(2.50)	
Uncertainty × Cross_postition				1.381**
				(2.09)
Uncertainty	−0.128	0.231	0.129	0.374***
	(-0.64)	(1.51)	(0.76)	(2.86)
SOE	0.355***			
	(7.86)			
Political_connection		−0.134***		
		(-3.07)		
Party_ratio			0.114	
			(1.25)	
Cross_postition				0.115
				(0.90)
Constant	−3.122***	−3.907***	−3.714***	−3.892***
	(-7.85)	(-10.05)	(-9.42)	(-9.98)
Observations	25,694	25,694	25,694	25,694
Pseudo R^2	0.135	0.121	0.122	0.122
Control	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Ind FE	Y	Y	Y	Y

Table 10 presents a table testing whether SOE identity, firm-level political connection or embeddedness play a risk shield or enhance political pressure for firm's risk management. Definitions of variables are provided in Table A3. D&O insurance demand (Doins) functions as dependent variable. T-values are reported in parentheses. Year and industry fixed effects are controlled to mitigate confounding effects from unobserved variables. Robust standard errors are used in the regression analysis. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

The results of political embeddedness are quite similar, the coefficients of *Uncertainty* × *Party_ratio* and *Uncertainty* × *Cross_postition* are also significantly positive at least at 5 % level(1.248, $p < 0.05$). These results indicate that such political connections or embeddedness do not act as a substitute for mitigating a firm's risk. Column (4) shows a positive and significant effect for Uncertainty × Cross_position (1.381, $p < 0.05$), meaning that firms with cross-positions in management or ownership are more likely to boost their D&O insurance demand during periods of uncertainty. Instead, they enhance the firm's risk aversion and ultimately increase the demand for risk management.

4.4. Robustness and endogeneity check

4.4.1. Exogenous event shock to uncertainty

Considering the potential for tone manipulation in annual reports when relying solely on a textual analysis method, as well as the issue of reverse causality, we further employ exogenous events that affect firms' perceptions of uncertainty as alternative measures. We then test how changes in firms' D&O insurance demand respond to these events. We posit that the occurrence of a natural disaster within the province where a firm is located imposes uncertainty on the firm's operations (He et al., 2022). This event is clearly exogenous and could significantly disrupt firm operations. Additionally, both firm-level relocation (Chen et al., 2020) and the turnover of the chairman of the board (Bushman et al., 2010; Firth et al., 2006) may also increase uncertainty in decision-making processes.

Table 11
Exogenous shock on firms' uncertainty and D&O insurance demand.

	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
Disaster	0.117***		
	(3.47)		
Relocate_province		0.341**	
		(2.05)	
Chairman_turnover			0.213***
			(5.20)
Size	0.080***	0.092***	0.092***
	(4.96)	(5.89)	(5.90)
ROE	−0.226**	−0.212*	−0.181
	(-2.01)	(-1.91)	(-1.63)
Leverage	0.592***	0.559***	0.540***
	(6.36)	(6.07)	(5.89)
Inde_ratio	0.750***	0.763***	0.726**
	(2.58)	(2.63)	(2.50)
Dual	−0.317***	−0.326***	−0.320***
	(-8.45)	(-8.70)	(-8.55)
Top1	−0.527***	−0.562***	−0.568***
	(-5.27)	(-5.66)	(-5.69)
Board	0.073	0.075	0.061
	(0.87)	(0.90)	(0.73)
Big4	0.614***	0.605***	0.608***
	(10.66)	(10.50)	(10.52)
Oversea_ratio	0.762***	0.756***	0.772***
	(7.38)	(7.32)	(7.48)
Constant	−3.533***	−3.789***	−3.744***
	(-8.96)	(-9.77)	(-9.66)
Observations	25,694	25,694	25,672
Pseudo R^2	0.120	0.119	0.121
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Table 11 presents a table using three shocks that are highly related to firm-level uncertainty perception as independent variables to test the robustness of our conclusions. D&O insurance demand (Doins) functions as dependent variable. Definitions of the variables are provided in Table A3. T-values are reported in parentheses. Year and industry fixed effects are controlled to mitigate confounding effects from unobserved variables. Robust standard errors are used in the regression analysis. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Results tabulated in Table 11 show that in column (1), the coefficient for *Disaster* is positive and highly significant (0.117, $p < 0.01$), indicating that natural disasters significantly increase D&O insurance demand, suggesting these events elevate firms' perceived risks. In column (2), the coefficient for *Relocate_province* is positive and significant (0.341, $p < 0.05$), showing that relocating the firm to a new province increases D&O insurance demand. In column (3), *Chairman_turnover* is also positive and highly significant (0.213, $p < 0.01$), suggesting that changes in a firm's leadership (chairman turnover) raise the firm's demand for D&O insurance due to the associated uncertainties.

These results suggests that the uncertainty triggered by the relocation of firms at the provincial level, as well as the turnover of the board chairman, are significantly associated with D&O insurance demand.

4.4.2. Robustness: extra fixed effects and alternative models

There may be important factors influencing both uncertainty perception and D&O insurance demand that are not included in the analysis. These omitted variables might confound the relationship between uncertainty perception and insurance demand, potentially resulting in biased estimates. For instance, firms might purchase D&O insurance by merely following their peer firms or executives within their social networks (Hu and Fang, 2022), or due to variations in regional or industry-specific regulatory enforcement intensity (Park, 2018). However, as it is challenging to capture and control all these variables, a pragmatic approach to mitigate this issue is to incorporate additional fixed effects and their interactions.

Province fixed effects capture regional variations in economic, regulatory, and legal environments that could affect both uncertainty perception and insurance demand differently across provinces. Incorporating interactions among year, industry, and province fixed effects helps to demonstrate the reliability of the findings regarding the association between firm-level uncertainty perception and D&O insurance demand. This approach accounts for time, industry, and region-specific factors that might otherwise confound the results. By interacting with these fixed effects, the analysis controls for the combined influence of these factors, thereby isolating the effect of firm-level uncertainty perception on D&O insurance demand and enhancing the robustness and validity of the results.

Table 12 presents the results of robust checks conducted using an extended sample period, additional fixed effects, and an alternative model specification to assess the stability and consistency of the relationship between uncertainty and the demand for D&O insurance (Doins). Panel A reruns our baseline results using extended sample period(2020–2022). In column (1) and (2), uncertainty is found to have a significant positive effect on D&O insurance demand, with a coefficient of 0.474 (t-statistic = 5.32) and 0.211 (t-statistic = 2.24), and the model includes control variables, year fixed effects (Year FE), and industry fixed effects (Ind FE). From panel B in Table 13, we could observe that the coefficient of *Uncertainty* remains significantly positive is 0.573) after imposing multiple FE for year, industry, province in Column (1). These effects persist after incorporating the interactions between year-industry, year-province, province-industry, and year-industry-province FE in Columns (2)–(5). These results confirm the credibility of our baseline results.

The robustness checks, as illustrated in panel C and D, reaffirm the validity of our baseline results under alternative regression models. Both the panel logit and Tobit models produce consistently significant positive coefficients for uncertainty across all specifications (0.964, $p < 0.01$ in Panel Logit Model, and 0.817, $p < 0.01$ in Tobit Model), confirming that the demand for D&O insurance increases with perceived uncertainty. The inclusion of alternative measures for uncertainty (*Uncertain_N* and *Uncertain_NL*) also yields similar results, further strengthening the robustness of the findings. These consistent findings across different model specifications highlight the robustness of our conclusion that uncertainty drives the demand for D&O insurance.

Table 12
Robustness: extended sample period, extra fixed effects and alternative model.

Panel A: Extended sample period			(1)	(2)	
VARIABLES			Doins	Doins	
Uncertainty			0.474***	0.211**	
			(5.32)	(2.24)	
Constant			−1.427***	−5.575***	
			(-10.70)	(-22.58)	
Observations			37,711	37,711	
R-squared			0.210	0.273	
Year FE			Y	Y	
Ind FE			Y	Y	
Panel B: Extra FE	(1)	(2)	(3)	(4)	(5)
VARIABLES	Doins	Doins	Doins	Doins	Doins
Uncertainty	0.573***	0.481***	0.496***	0.618***	0.599***
	(4.41)	(3.73)	(3.01)	(4.87)	(4.49)
Constant	−4.140***	−3.766***	−5.712***	−5.563***	−5.291***
	(-10.20)	(-6.66)	(-6.04)	(-12.96)	(-10.69)
Observations	25,357	23,350	13,648	23,946	23,946
Control	Y	Y	Y	Y	Y
Year FE	Y	Y		Y	Y
Ind FE	Y	Y	Y		Y
Province FE	Y		Y	Y	Y
Year-Ind FE		Y			
Year-Province FE				Y	
Ind-Province FE			Y		
Year-Ind-Province FE					Y
Panel C: Panel logit:		(1)	(2)	(3)	
VARIABLES		Doins	Doins	Doins	
Uncertain		0.964***			
		(3.73)			
Uncertain_N			0.993***		
			(3.82)		
Uncertain_NL				0.989***	
				(3.82)	
Constant		−9.107***	−9.121***	−9.120***	
		(-11.10)	(-11.11)	(-11.11)	
Observations		25,694	25,694	25,694	
Pseudo R^2		0.118	0.118	0.118	
Control		Y	Y	Y	
Year FE		Y	Y	Y	
Ind FE		Y	Y	Y	
Panel D: Tobit		(1)	(3)	(5)	
VARIABLES		Doins	Doins	Doins	
Uncertain		0.817***			
		(3.49)			
Uncertain_N			0.840***		
			(3.59)		
Uncertain_NL				0.837***	
				(3.59)	
Constant		−8.556***	−8.567***	−8.566***	
		(-12.18)	(-12.19)	(-12.19)	
Observations		26,654	26,654	26,654	
Pseudo R^2		0.104	0.104	0.104	
Control		Y	Y	Y	
Year FE		Y	Y	Y	
Ind FE		Y	Y	Y	

Table 13 displays the results using extended sample period (2020–2022), multi-level fixed effects (FEs) from the year, industry, province, and their interactions. D&O insurance demand (Doins) functions as dependent variable. Column (1) shows the results with FEs for the year, industry, and province, while Columns (2) to (5) provide results with FEs for the year and industry, industry and province, the year and province, as well as their interactions respectively, addressing potential issues related to omitted variables. Robust standard errors are used in the regression analysis. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

4.4.3. *Lagged independent variables and instrumental variables*

A common issue in time series analysis is the simultaneous effects of changes in dependent and independent variables on each other. Consequently, another potential source of endogeneity that might compromise the credibility of our baseline results is reverse causality bias. For example, firms facing higher levels of uncertainty may seek more insurance coverage; however, simultaneously, more insurance coverage could influence their perception of uncertainty. Failure to address this endogeneity may result in biased relationship estimates. Lagging the independent variable enhances its exogeneity, as its prior value at time $t-1$ is less likely to be influenced by contemporaneous changes in the dependent variable at time t. This temporal separation reinforces the assumption of exogeneity and mitigates the issue of simultaneous causality, a vital prerequisite for unbiased estimation in regression analysis. This methodological strategy addresses potential reverse causality by positioning the independent variable in the past,

Table 13
Endogeneity test: lagged independent variable and instrumental variables.

Panel A: Lagged independent variable	(1)	(2)	(3)
VARIABLES	Doins	Doins	Doins
L.Uncertainty	0.352**		
	(2.53)		
L.Uncertainty_N		0.355**	
		(2.55)	
L.Uncertainty_NL			0.353**
			(2.55)
Constant	−3.545***	−3.548***	−3.547***
	(-8.48)	(-8.49)	(-8.49)
Observations	22,182	22,182	22,182
Pseudo R^2	0.113	0.113	0.113
Control	Y	Y	Y
Year FE	Y	Y	Y
Ind FE	Y	Y	Y

Panel B: Instrumental variables method	(1)	(2)
VARIABLES	Doins	Doins
Prov_EPU	0.000***	
	(3.33)	
INDMean_Uncertainty	0.567***	
	(23.77)	
Uncertainty		1.479*
		(1.91)
Constant	0.206***	−5.844***
	(13.95)	(-16.86)
Observations	26,596	26,596
Pseudo R^2	0.047	
Control	Y	Y
Year FE	Y	Y
F test	77.79(0.000)	
Wald chi2(P value)	3.66 (0.0557)	

Table 13 presents the results using a 1-year lagged uncertainty perception as the independent variable to address potential endogeneity issues in Panel A. Panel B tabulates the IV test results, where Prov_EPU is defined as provincial news-based economic policy uncertainty, and INDMean_Uncertainty is defined as the industrial average uncertainty perception, excluding the firm itself, as instrumental variables. D&O insurance demand (Doins) functions as dependent variable. Definitions of variables are provided in Table A3. T-values are reported in parentheses. Year and industry fixed effects are controlled to mitigate confounding effects from unobserved variables. Robust standard errors are used in the regression analysis. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

thus reducing the probability that it is simultaneously determined with the dependent variable. Table 13 Panel A presents the results using a one-year lagged independent variable in regression analysis. In Panel A, lagged uncertainty is positive and significant across all models, with coefficients ranging from 0.352 to 0.355 ($p < 0.05$), showing that past uncertainty increases current D&O insurance demand. The models control for year and industry fixed effects, with a sample of 22,182 firm-year observations. These results corroborate the credibility of our baseline findings.

Instrumental variables and two-stage regression methods are employed to address the reverse causality issue. Following Yu et al. (2021) and Jiang et al. (2022), we use both the provincial news-based economic policy uncertainty (*PROV_EPU*) and the average firm-level uncertainty in the same industry (*INDMean_Uncertain*) as the instrumental variables. In Panel B, the instrumental variables approach confirms the positive impact of uncertainty on D&O insurance demand. Prov EPU (provincial economic policy uncertainty) and INDMean_Uncertainty are both positive and significant ($p < 0.01$), indicating that higher policy and industry-level uncertainty increase D&O insurance demand. The coefficient for Uncertainty in Model (2) is also significant (1.479, $p < 0.10$). The results, based on 26,596 firm-year observations, highlight the robustness of the relationship between uncertainty and D&O insurance demand, whether using lagged or instrumental variables.

In summary, the results in this section suggest that our findings are likely to be robust to different measurement selections. Additionally, we have made a concerted effort to address endogeneity issues, including variable omission and reverse causality, to further confirm the robustness of our main conclusion.

5. Conclusion

This paper investigates how firm-level uncertainty perceptions influence the demand for D&O liability insurance as a strategy to manage risks and maintain corporate legitimacy. We find that uncertainty significantly increases firms' insurance demand, particularly among those facing higher litigation risks or constrained financial resources. However, this effect is mitigated when firms exhibit stronger legitimacy signals—such as anti-corruption measures and gender-diverse leadership—suggesting that D&O insurance also serves as a legitimacy-enhancing tool.

External and internal governance factors shape this relationship. Firms in more marketized regions or with higher audit quality rely less on insurance, while those facing internal control deficiencies or audit risks show higher demand. Additionally, digital transformation, financialization, and ESG engagement serve as substitutes for D&O insurance under uncertainty by enhancing internal resilience and reputation. Contrary to prior findings, political connections and state ownership do not reduce insurance demand—instead, they amplify it, likely due to heightened risk aversion under political scrutiny.

Theoretically, this study integrates uncertainty and legitimacy perspectives, showing that firms use D&O insurance not only to hedge risks but also to signal responsible governance. Practically, it suggests that developing economies should enhance financial system diversity, strengthen legal frameworks, and improve internal controls to reduce uncertainty and promote sustainable corporate behavior. For instance, encouraging D&O insurance adoption and improving governance protections can attract qualified executives and enhance corporate resilience.

This study has the following limitations. Firstly, regarding data, since China does not mandate the disclosure of insurance premiums and limits, we were unable to examine the association between firms' perceptions of uncertainty and D&O insurance premiums. This variable, as an explanatory factor, could offer a more precise measure of company-level risk pricing, but only for the limited sample of data that has been disclosed. Secondly, we chose to measure general uncertainty using companies' MD&A text. Although economic policy uncertainty, as utilized in existing literature, may offer more targeted insights, it is not directly related to insurability. In future research, it would be beneficial to explore the construction of uncertainty perception based on legal risk, which has a direct logical connection to companies' D&O insurance.

Author contributions

Conggang Li improved the empirical analysis and interpretation, reviewed and edited the manuscript; Yijun Liu contributed to the conception and design of the study, performed the data collection, conducted the data analysis and interpretation, wrote the first draft of the manuscript; Rong Xu and Xingmei Xu reviewed and edited the manuscript; all authors read and approved the final manuscript.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent to participate

Not applicable.

Consent for publication

All authors consent to the publication of the manuscript in ***Economic Modelling***.

Declaration of generative AI in scientific writing

During the preparation of this work the authors used ChatGPT4 in order to grammar check. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A.1
Uncertainty keyword list for textual analysis.

Uncertainty Keyword list	
Uncertainty	(bu4que4ding4, bu4ming2que4),
Unclear	(bu4ming2lang3, wei4ming2),
Unexpected	(nan2liao4, nan2yi3gu1ji4, nan2yi3yu4ji4, nan2yi3yu4ce4, nan2yi3yu4liao4),
Risks	(feng1xian3, wei1xian3),
Crisis	(wei1ji1),
Threat	(wei1xie2),
Unknown	(wei4zhi1)

Table A.2
Correlation analysis for key variables.

	Uncertainty	Size	ROE	Leverage	Inde_ratio	Dual	Top1	Board	Big4	Oversea_ratio
Uncertainty	1									
Size	−0.0039	1								
ROE	−0.0650*	0.0808*	1							
Leverage	0.0840*	0.5155*	−0.1874	1						
Inde_ratio	−0.0173	−0.0300*	−0.0111	−0.0256*	1					
Dual	−0.0695*	−0.1794*	0.0261*	−0.1485*	0.1128*	1				
Top1	0.0344*	0.1783*	0.1329*	0.0410*	0.0395*	−0.0299*	1			
Board	0.0259*	0.2503*	0.0248*	0.1503*	−0.5448*	−0.1760*	0.0169	1		
Big4	0.0008	0.2069*	0.0506*	0.0638*	0.0058	−0.0403*	0.1201*	0.0428*	1	
Oversea_ratio	−0.0730*	0.0766*	0.0430*	−0.0376*	0.0454*	0.0700*	−0.0306*	−0.0531*	0.1285*	1

Table A.3
Key Variable definition.

Variable	Definition
Uncertainty	Uncertainty related words/total number of words in the MD&A section × 100 %
Uncertainty_N	Uncertainty related words/total number of words except for digits in the MD&A section × 100 %
Uncertainty_NL	Uncertainty-related words/total number of words except for digits and letters in the MD&A section × 100 %
Revised uncertainty	Uncertainty measurement using Word2Vec.
Doins	Dummy variable marked as 1 for firm with D&O insurance, zero otherwise
Size	Logarithm of total assets
ROE	Return on equity
Leverage	Firm's total debt/total assets
Inde_ratio	Ratio of independent directors
Dual	Dummy variable marked as 1 for firm with chairman and the CEO are the same person, zero otherwise
Top1	Shareholding ratio of the largest shareholder
Board	Logarithm of number of board member
Big4	Dummy variable remarked as one for firm have big 4 audit, zero otherwise
Oversea_ratio	Ratio of firms' directors with oversea experience among all directors
Violation	Dummy variable marked as 1 for firm with violation record in the given year, zero otherwise

(*continued on next page*)

Table A.3 (*continued*)

Variable	Definition
Litigation	Dummy variable marked as 1 for firm with litigation record in the given year, zero otherwise
LnLitigation_amount	Logarithm of number of board member
Cash_holding	Ratio of net cash flow to total assets
Z_score	Measurement for financial distress calculated as 1.2 × Working Capital to Total Assets +1.4 × Retained Earnings to Total Assets +3.3 × EBIT to Total Assets+0.6 × Market Value of Equity to Total Liabilities+1.0 × Sales to Total Assets
KZ_index	KZ Index measure firm's financial constraints based on factors like cash flow, capital expenditure, dividend payments, leverage, and firm size, with higher values indicating greater financial constraints
Marketization	Marketization index assesses the progress and degree of market-oriented economic across different regions developed by Fan and Wang
Legislation	Legal environment index assesses the development of regional legal environment developed by Fan and Wang
Non_state	Non state economic development index assesses the development of the development of the non-state sector developed by Fan and Wang
Freq_Audit_committte	Number of meetings from audit committee in a given year
Digitalization	Digitalization related words/total number of words in the MD&A section × 100 %
Financialization	Ratio of financial assets to total assets
ESG	ESG rating from Sino securities
SOE	Dummy variable marked as 1 for firm with litigation record in the given year, zero otherwise
Political_connection	Dummy variable marked as 1 for firm with political connection (national level deputy from NPC or PCC), zero otherwise
Party_ratio	Ratio of executives with CCP affiliations
Cross_postition	Dummy variable marked as 1 for firm with chairman of the board and chairman of the party committee are the same person, zero otherwise
Disaster	Dummy variable marked as 1 for firm located in province with natural disaster in the given year, zero otherwise
Relocate_province	Dummy variable marked as 1 for firm relocated to another province in a given year, zero otherwise
Chairman turnover	Dummy variable marked as 1 for firm experience chairman turnover in the given year, zero otherwise

Table A.3 presents the definitions of all major variables.

Table A.4
D&O insurance industrial distribution

Industry	#Doins	Total	D&O insurance coverage
Computer, Communications, and Other	979	4511	21.70 %
Pharmaceutical Manufacturing	599	2779	21.55 %
Electrical Machinery and Equipment Manufacturing	588	2859	20.57 %
Special Equipment Manufacturing	551	2793	19.73 %
Chemical Raw Materials and Products	548	3097	17.69 %
Software and IT Services	540	2431	22.21 %
General Equipment Manufacturing	341	1712	19.92 %
Real Estate	338	1716	19.70 %
Financial Services	261	380	68.68 %
Automotive Manufacturing	244	1503	16.23 %
Non-metallic Mineral Products	243	1164	20.88 %
Wholesale	228	949	24.03 %
Capital Market Services	227	504	45.04 %
Power and Heat Production	218	953	22.88 %
Retail	212	1240	17.10 %
Rubber and Plastic Products	180	983	18.31 %
Civil Engineering	158	750	21.07 %
Rail, Ship, Air, and Aerospace	151	648	23.30 %
Non-ferrous Metal Smelting	148	873	16.95 %
Water Transport	135	377	35.81 %
Food Manufacturing	134	585	22.91 %
Metal Products	134	809	16.56 %
Internet Services	126	583	21.61 %
Business Services	125	543	23.02 %
Environmental Protection	122	405	30.12 %
Agricultural Processing	109	622	17.52 %
Ferrous Metal Smelting	107	442	24.21 %
Road Transport	99	402	24.63 %
Professional Services	95	466	20.39 %
Non-ferrous Metal Mining	92	297	30.98 %
Paper Products	92	409	22.49 %
Instruments and Meters	88	591	14.89 %
Beverages and Refined Tea	85	551	15.43 %
Air Transport	75	150	50.00 %
Coal Mining	69	352	19.60 %
Textile	69	578	11.94 %
Insurance	67	76	88.16 %
Water Supply	62	199	31.16 %
Public Facility Management	56	229	24.45 %
Apparel and Accessories	56	456	12.28 %
Media and Publishing	55	240	22.92 %
Gas Supply	54	237	22.78 %
Chemical Fiber Manufacturing	53	342	15.50 %
Specialized Mining	52	176	29.55 %
Other Financial Services	51	128	39.84 %
Research and Development	47	104	45.19 %
Telecommunications and Broadcasting	44	218	20.18 %

(*continued on next page*)

Table A.4 (*continued*)

Industry	#Doins	Total	D&O insurance coverage
Oil, Coal, and Fuels	42	234	17.95 %
News and Publishing Industry	41	264	15.53 %
Agriculture	40	208	19.23 %
Furniture Manufacturing	37	217	17.05 %
Oil and Gas Extraction	30	73	41.10 %
Other Manufacturing	30	267	11.24 %
Construction and Decoration	29	323	8.98 %
Healthcare	28	110	25.45 %
Cultural and Sports Services	28	190	14.74 %
Animal Husbandry	27	187	14.44 %
Education	24	63	38.10 %
Comprehensive	23	341	6.74 %
Leather and Related Products	22	123	17.89 %
Transport and Logistics	21	145	14.48 %
Wood Processing	19	118	16.10 %
Waste Utilization	16	69	23.19 %
Art and Culture	16	71	22.54 %
Printing and Media Replication	16	140	11.43 %
Mining and Selection (Black Metal)	15	75	20.00 %
Postal Services	13	34	38.24 %
Railway Transport	9	56	16.07 %
Accommodation	9	102	8.82 %
Logistics and Storage	8	102	7.84 %
Installation Services	7	21	33.33 %
Technology Promotion	6	15	40.00 %
Leasing	6	39	15.38 %
Non-metallic Mining	5	10	50.00 %
Catering	4	46	8.70 %
Fisheries	4	110	3.64 %
Housing Construction	3	34	8.82 %
Forestry	3	58	5.17 %
Sports	2	10	20.00 %
Agricultural Specialties	2	22	9.09 %
Land Management	1	1	100.00 %
Water Management	1	1	100.00 %
Other Services	0	15	0.00 %
Residential Services	0	6	0.00 %
Motor Vehicles and Electronics	0	6	0.00 %
Metal Products and Equipment	0	2	0.00 %
Total	9694	46,320	20.93 %

Table A.5
D&O insurance industrial distribution

Year	D&O insurance coverage		Total	D&O insurance coverage
	Without	with		
2010	2024	114	2138	5.33 %
2011	2247	125	2372	5.27 %
2012	2355	146	2501	5.84 %
2013	2391	159	2550	6.24 %
2014	2524	169	2693	6.28 %
2015	2749	184	2933	6.27 %
2016	3057	194	3251	5.97 %
2017	3398	226	3624	6.24 %
2018	3465	259	3724	6.95 %
2019	3626	314	3940	7.97 %
2020	3937	500	4437	11.27 %
2021	3374	1382	4756	29.06 %
2022	2661	2503	5164	48.47 %

Data availability

Data will be made available on request.

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