

Directors' and officers' liability insurance and digital transformation – the mediating role of explorative innovation

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Abstract

Purpose – The purpose of this paper is to investigate the relations between the directors' and officers' (D&O) insurance and digital transformation of Chinese-listed companies to provide insights into triggers of digital transformation from the perspective of D&Os' incentive plan.

Design/methodology/approach – Based on a panel dataset of 2,590 listed manufacturing companies in China from 2017 to 2020, and using a textual analysis of annual reports, this paper empirically examines the impact of D&O insurance on digital transformation. The authors investigate the mechanism through a mediating model and apply a series of robustness tests including firm fixed effect model, propensity score matching and changing key measures.

Findings – The research shows that the digital transformation has been negatively influenced by D&O insurance. The long coverage duration of D&O insurance significantly lowers the level of digital transformation. The moral hazard problem caused by D&O insurance has hampered digital transformation through reducing explorative innovation, while there has been no significant change in innovation quantity. Under the coverage of D&O insurance, firms with worse internal governance and state-owned firms are more reluctant to invest in risky transformation than their counterparts.

Originality/value – Based on a textual analysis of annual reports, this paper empirically tests the influential mechanism of D&O insurance coverage on digital transformation. The authors provide insights into non-tech triggers of digital transformation and uncover how incentive plans influences D&Os' behaviors. This paper provides a new angle to the debate on governance-strengthening and governance-weakening role of D&O insurance.

Keywords Digital transformation, D&O insurance, Explorative innovation, Managerial legal liability, Corporate governance

Paper type Research paper



1. Introduction

Digital transformation builds new competitive challenges, improves decision-making, creates competitive advantage and optimizes customer needs and experiences (Ardito *et al.*, 2019; Berghaus and Back, 2017; Haffke *et al.*, 2017; Osmundsen *et al.*, 2018; Ferreira *et al.*, 2019; Gong and Ribiere, 2021) and has a significant impact on innovation capacity (Matt *et al.*, 2015). Given the growing attention of digital transformation, what triggers digital transformation also attracted increasing interest from researchers. Earlier research has emphasized the technological features of digital transformation, such as the technical process of converting analog signals into a digital form (Legner *et al.*, 2017) or “the pace of change in a society driven

by digital technological development, involving multiple technologies at different stages of maturity that will converge and create new technologies” (McAfee and Andrew, 2009). In recent years, scholars have started paying more attention to non-tech aspects of digital transformation, for instance discussing which factors lead to successful digital transformation, such as organizational culture, internal and external knowledge, human capital and others (Bilgeri *et al.*, 2017; Firk *et al.*, 2021; Osmundsen *et al.*, 2018).

There has been a longstanding debate in understanding the economic consequences of directors’ and officers’ (D&O) liability insurance, which is an important component of incentive plan (Chi and Weng, 2014; Jia *et al.*, 2019). Firms buy D&O insurance to protect directors and officers from personal claims from their activities as representatives of the firm. The effects of D&O insurance are unclear. One argument is that D&O insurance monitors D&Os and benefits corporate governance. Following this argument, D&O insurance can stimulate digital transformation since it increases incentives of directors and officers to take risks for the benefit of the company (Lin *et al.*, 2011; Yuan *et al.*, 2016). Another argument is that D&O insurance hampers corporate governance (Chang *et al.*, 2018) because it reduces the effectiveness of litigations as an important part of external governance. Also, the information asymmetry between insurers and companies decreases the potential litigation costs of D&Os’ opportunistic behaviors. Since insurers cannot unreasonably withhold consent for payment of defense and settlement costs, they settle claims even when they suspect bad faith by D&Os (Chung and Wynn, 2008). The threat of shareholder litigation disciplines D&Os’ behavior and is viewed as an important monitoring mechanism. Under coverage of D&O insurance, the governance of litigation is weakened. Prior research has found that D&O insurance leads to high cost of equity, high acquisition premiums, low acquisition synergies, large loan spreads and increases financial tax management, among other things (Lin *et al.*, 2013; Zeng, 2017).

In addition to the non-tech antecedent of digital transformation, this paper identifies the mediating role of explorative innovation. Corporate innovation (explorative innovation VS exploitative innovation) differs in its degree of novelty and disruption (Jia *et al.*, 2019; Rothaermel and Deeds, 2004; Wang *et al.*, 2017). Firms that conduct explorative innovations explore in new technological field and create new knowledge. By contrast, firms that focus on exploitative innovation extend the prior technology trajectory without stepping into a new one. Innovative technologies are preliminary conditions that drive digital transformation. Also, firms that conduct exploitative innovation drive digital transformation by innovation push and culture support.

This paper aims to fill the research gap between D&O insurance and digital transformation and the mediating role of explorative innovation. By studying 2,590 listed manufacturing companies in China from 2017 to 2020, we find that D&O insurance is associated with a low level of digital transformation. The longer a firm is covered by D&O insurance, the lower the level of digital transformation. The mechanism test shows that D&O insurance negatively impacts a firm’s explorative innovation, which further impedes digital transformation. Interestingly, D&O insurance does not have a significant impact of innovation quantity, showing that directors may choose a more exploitative innovation strategy rather than an explorative one. Increasing innovation quantity by exploitation is also a signal of managerial myopia, since exploitation leads to short-term growth, stability and efficiency but harms long-term advantage. In cross-sectional analysis, the results show that firms with worse internal governance and state-controlled firms that covered by D&O insurance are more reluctant to conduct digital transformation. After controlling for other incentive plan, controlling for firm fixed effects, a propensity score matching method and alternative measures of digital transformation, the results still hold.

This paper makes three contributions. First, we examine whether incentive plan, especially D&O insurance, affects digital transformation based on corporate governance theory. The extant D&O insurance literature does not provide a clear answer due to the controversial role of such insurance. By examining whether D&O insurance makes D&Os

willing to engage in risk-taking activities (represented by digital transformation), this paper enriches current debate on the topic.

Second, we provide evidence on a specific channel through which D&O insurance influences digital transformation. We find that D&O insurance does not decrease innovation quantity. Instead, D&O insurance coverage lead to a less explorative innovation strategy. D&O insurance negatively affects digital transformation by hampering explorative innovation. The channel provides insights into the conversation about whether D&O insurance coverage results in opportunistic behaviors and expands the literature on the relationship between innovation and digital information.

Third, this paper uncovers a new factor that affects digital transformation, adding to the literature about what triggers and impedes digital transformation. The literature has identified how managers drive digital transformation theoretically. Recently, scholars have paid attention to the role of the chief digital officer. However, it remains unclear how D&Os' incentive plan affects their behavior and decision-making toward digital transformation. This paper complements current research by identifying a new micro-level antecedent of digital transformation.

The remainder of the paper is structured as follows. In [section 2](#), we briefly review D&O insurance and digital transformation in China. [Section 3](#) discusses the research methods, and [section 4](#) provides descriptive statistics and empirical analysis, and additional analysis is given in [section 5](#). [Section 6](#) shows a mechanism identification, and [section 7](#) concludes.

2. Institutional background, literature and hypotheses

2.1 Digital transformation literature and institutional background

The impact of digital transformation is attracting increased attention. Prior research finds that the definition of digital transformation is unified ([Gong and Ribiere, 2021](#)). Some scholars have emphasized the technical part and defined digital transformation as “the technical process of converting analog signals into a digital form” and “the pace of change in a society driven by digital technological development” ([Legner et al., 2017](#)). Some scholars have viewed digital transformation as a new ERP system (e.g. [Gong and Ribiere, 2021](#)). However, an increasing number of studies have stated that digital transformation is an on-going company-wide initiative requiring technical and cultural changes (e.g. [Hanelt et al., 2021](#)). Digital transformation is less about adding technology to the production line and more about changing all aspects of the business from processes to culture, starting with the pervasive mindsets held by individual and as a collective organization ([Jones et al., 2021](#); [Liere-Netheler et al., 2018](#)).

According to the White Paper on China's Digital Economy Development (2021), the digital economy reached a scale of 39.2 trillion RMB in 2020, rising rapidly from 28.8 trillion RMB in 2019. Digital economy accounted for 38.6% of China's GDP in 2020. In a period when the uncertainties of global economic and trade have soared, together with increasing downward pressure on the economy, the Chinese government has announced a series of policies to promote corporate innovation and achieve self-dependent innovation. Under this context, digital transformation is believed to be a core driving force for the high-quality development of China's economy. Early in 2012, China promulgated the “12th Five-Year Plan” to promote the integration of information and industrialization. The Chinese government then issued the notice of an action plan to promote the development of big data in 2015. In 2021, the Government Work Report further emphasized the development of digital transformation. Digital transformation is receiving increasing attention from shareholders. Before 2020, there were more than 3,000 cases of digital transformation-related questions from investors, but 2020 to 2021, the number of digital transformation-related questions increased by 52% [[1](#)].

The amount of research on digital transformation is also increasing significantly. From an information view, digital transformation can increase analyst coverage and accuracy of

public information through channels of information disclosure quality and stock price information content (Chen *et al.*, 2022). In a study of Chinese manufacturing corporations, digital transformation can improve innovation capabilities since corporations can utilize digital transformation to achieve scale advantages of innovation investment and cost control (Tian *et al.*, 2022). However, Tian *et al.* (2022) also pointed out that digital transformation is not a panacea, and it increases firms' risk-taking by positively influencing operating flexibility and financing access. Scholars have emphasized the risks and challenges of digital transformation in the following aspects.

- (1) Technological risks. Digital technology, such as big data, cloud computing and product virtualization, can lead to disruptions (Berghaus and Back, 2017). Firms implement innovative digital technologies and employees need to leverage these technologies until they become digital transformers. It is hard for entire organizations to build up such dynamic abilities.
- (2) Internal and external tensions. As an organization pursues a digital business strategy, misalignments between the emergent strategy and resources can give rise to internal tensions (Yeow *et al.*, 2017). Digital transformation need coordination among various departments. Traditionally, an information technology department is not often in a central position. The influences of digital transformation are heterogeneous for different departments. The potential interest conflicts makes it hard for an exchange of materials, data and information within an organization. Externally, digital transformation brings customers reimagining products and services and changes the production circle and ways of delivering information (Jones *et al.*, 2021). It is also crucial that customers accept changes caused by digital transformation.
- (3) Data security risks. For digital transformation to achieve the desired results, a collection of structured and unstructured data is required (Tripathi and Gupta, 2019). In the process of data collection, delivery, transmission, storage, usage, sharing and destruction, firms are exposed to data security risks. The issue of data theft, security breaches and cyber-attacks can lead to unbearable and unpredictable loss. Taking external data as an example, there is still a lack of established regulations on the range of data sharing, which can easily lead to compliance risks.

To accomplish digital transformation, the organization must combine a series of drivers: (1) Innovation push – innovative technologies, such as big data, cloud computing and product virtualization, are preliminary conditions that drive digital transformation. (2) Supportive organizational culture – an organizational value, such as openness to new ideas, willingness to change, tolerance of risk and embrace of new opportunities, is essential for the success of digital transformation. (3) Human capital driver – human capital not only refers to the management team, but also employees. Managers decide the visions and strategies of digital transformation. They are in charge of arranging resources, setting up structures, hiring employees and designating tasks. Supportive employees are also crucial in implementing relevant strategies.

Regardless of the vigorous digital transformation policies and practices, less is known about what drives digital transformation, especially at a firm and personal level. There is no doubt that digital transformation is not an over-night change. What motivates digital transformation remains unsolved. We provide evidence from the angle of D&O insurance in next section.

2.2 D&O insurance literature and institutional background

D&O insurance covers D&Os for legal liability arising from their professional activities on behalf of the company (Yuan *et al.*, 2016). D&O insurance covers litigation costs for claims

made against individual directors and officers for wrongful acts and can protect D&Os from their personal legal liability. Prior research has found that the incidence of D&O insurance demand comes from controlling-minority shareholder incentive conflicts (Zou *et al.*, 2008). Since D&Os are often involved in expropriation activities that increases their exposure to litigation risk, firms buy D&O insurance to hedge litigation risks. Another study on Chinese firms found that political connection negatively influence demand for D&O insurance (Jia *et al.*, 2019) since political connection has already secured D&Os from some litigation risks.

D&O insurance is widely used in developed markets, such as the United States, where D&O insurance originated. It has been reported that 97% of US corporations and 86% of Canadian corporations have bought D&O insurance (Yuan *et al.*, 2016). Compared with the high proportion of D&O insurance coverage in developed countries, D&O insurance in China has distinguished features as well as economic effects. D&O insurance started late in China. In 2002, China's insurance company, China PingAn Insurance Co., Ltd. and Chubb Insurance Group introduced D&O insurance into China. As the Chinese Company Law and Securities Law stipulates that shareholders can sue boards of D&Os, D&Os face an increased risk of litigation (Jia and Tang, 2018). Compared to developed economies, the monitoring role of D&O insurance in China is weak since insurers lack experiences in establishing experienced team, design proper insurance clauses and provide evidence for D&Os' deliberate frauds. In 2020, after revision of the Securities Law, the violation cost and litigation risk of D&Os increased significantly. To introduce a system of registration for issuing stocks (instead of authorized system), the new Securities Law protects investors by promoting punishment for fraudulent disclosure. Anticipating increasing personal litigations, an increasing number of corporations have bought D&O insurance. However, current research on D&O insurance fails to agree on a common format.

There is no consensus whether D&O insurance weakens governance or strengthens it. One stream of literature finds that D&O insurance can play the role of monitoring D&Os' behaviors. D&O insurance benefits firms in terms of recruiting and retaining talents (Brook and Ramesh, 1994; Chang *et al.*, 2018) as well as introducing insurance company as an external monitor (Chang *et al.*, 2018). Research has found that D&O insurance increases firm value (Hwang and Kim, 2018). In the context of China, the governance characteristics of Chinese corporations are represented by a highly concentrated ownership structure, ineffective boards of supervisors and controlling government shareholding (Jia *et al.*, 2019; Yuan *et al.*, 2016). Insurance companies will actively monitor firm behaviors (Li *et al.*, 2022). From this perspective, D&O insurance can strengthen corporate governance. Studies have found that D&O insurance can decrease the risk of stock price crash, positively influence firm innovation and lower bond spread (Li *et al.*, 2022; Wang *et al.*, 2020; Yuan *et al.*, 2016).

However, the opposite view argues that D&O insurance can increase moral hazard and lead to opportunistic behavior. D&O insurance shields D&Os from litigation risks. Without the threat of law suits, they are less likely to make decisions in the best interests of corporations (Li *et al.*, 2022). There is evidence that D&O insurance increases litigation risk and leads to lower M&A synergies (Gillan and Panasian, 2015). The reasons are twofold (Lin *et al.*, 2011): Firstly, D&O insurance reduces the effectiveness of threat of shareholder litigation as a governance mechanism. The effectiveness of external governance is reduced via D&O insurance, leading to unintended moral hazard. D&O insurance protects directors and officers from potential loss in litigation. Secondly, the information asymmetry between insurers and firms leads to failure of issuers monitoring. Insurers settle claims even when they suspect bad faith by D&Os (Chung and Wynn, 2008).

To sum up, Chinese institutional background provides an opportunity to study the monitoring role of D&O insurance. As the demand and purchase of D&O insurance increases, issuers are likely to be more effective at improving corporate governance and the moral hazard problem.

2.3 Hypotheses

Digital transformation initiates firm-wide changes of technology, culture, human capital, business model and competencies (Jones *et al.*, 2021). It is not solely about adding digital technology to traditional business and is more about changing all aspects including pervasive mindsets (Jones *et al.*, 2021). Corporate governance theory indicates that D&Os may not conduct digital transformation that has a risky nature and may harm their personal interests. Superior internal governance facilitates digital transformation in the following two aspects: on one hand, superior internal governance reduces D&Os' opportunistic behaviors and they act in the best interest of the company. Although digital transformation brings challenges in terms of coordination, technological innovation and organizational change, D&Os are more likely to overcome such challenges under internal governance. On the other hand, as superior internal governance reduces the moral hazard problem, D&Os will work hard to drive digital transformation. For example, expanding their vision, hiring employees and designating tasks.

Internal governance influences not only technical factors but also non-tech ones. Digital technologies, such as cloud computing, big data and information technology, are critical elements of digital transformation (Li *et al.*, 2019; Lu *et al.*, 2020). Despite technological issues, scholars have emphasized that organizational and managerial problems are challenges that corporations will navigate. The requirement to shift corporate strategy and competencies toward a differential way is a challenging decision to make (Firk *et al.*, 2021). For instance, managers and employees should be careful that the direction of transformation activities is providing value to customers and managers need to coordinate cross-division conflicts (Firk *et al.*, 2021; Shaughnessy, 2018). To sum up, digital transformation is born with a disruptive, challenging and risk-taking nature since the success of digital transformation requires collective efforts from both tech and non-tech aspects.

The influence of D&O insurance on digital transformation is not *a priori* obvious. D&O insurance changes the risk environment that D&Os face, so their decision-making may be affected. On one hand, D&O insurance protects D&Os from litigation risks and motivates them to be aggressive. D&O insurance covers D&Os for their wrongful acts, such as damages, judgments and litigation expenses. They worry less about being sued if they do something wrong during the process of digital transformation. The increasing risk tolerance allows D&Os to accept risky but valuable activities, including tech and non-tech changes brought by digital transformation. Taking external coordination as an example, digital transformation requires multiple inter-organization communications that may cause tensions and conflicts (Tumbas *et al.*, 2018). The coverage of D&O insurance offers D&Os such risk compensation and motivates D&Os to carry forward transformation activities (Hsu *et al.*, 2022; Manso, 2011). As a safeguarding role, D&O insurance also attracts talent with advanced management skills. The importance of attracting, hiring and keeping human capital with talents are emphasized (Osmundsen *et al.*, 2018).

On the other hand, D&O insurance may also negatively impact digital transformation, especially in emerging markets. Firstly, D&O insurance weakens the external governance role of litigation threats. Threat of shareholder litigation disciplines D&Os' behavior and is viewed as an important monitoring mechanism (Osmundsen *et al.*, 2018). D&O insurance transfers D&Os' legal liability to insurance companies, reduces the expected legal liability and weakens the threat of legal punishment. The effectiveness of external governance is lightened via D&O insurance, leading to unintended moral hazard. This is consistent with the argument that D&O insurance increases the incentive of D&Os to behave in their own best interests, rather than the best interests of stakeholders. For example, D&Os who opportunistically exploit IPO overpricing to sell overvalued equity will buy D&O insurance to protect themselves from financial loss in shareholder litigation. Secondly, D&O insurance reduces the potential costs of directors and manager's opportunistic

behaviors and then hampers digital transformation. D&Os' decisions are determined by the net utility of benefit minus cost. D&O insurance provides compensation for D&Os' litigation costs by reimbursing the D&Os' costs in defending and settling lawsuits. Due to lowered costs of lawsuits, managers may make decisions that are not in the best interests of their organization. Also, the information asymmetry between insurers and companies increases D&Os' temptation to engage in opportunistic activities. The most typical exclusions from D&O insurance are suits based on deliberate fraud. Since insurers cannot unreasonably withhold consent for payment of defense and settlement costs, they settle claims even when they suspect bad faith by D&Os (Chung and Wynn, 2008). To avoid potential payment of refusing a good faith settlement offer, the insurer settles claims (Core, 2000). As mentioned before, D&O insurance has been introduced into China for about 20 years. Compared to developed economy, insurers in China face immature laws and regulations and they have not accumulated sufficient experience in D&O insurance cases. D&O insurance causes moral hazard problem and hampers D&Os' ambition to make disruptive changes. Therefore, D&O insurance negatively influences digital transformation.

H1a. Ceteris paribus, D&O insurance positively impacts digital transformation

H1b. Ceteris paribus, D&O insurance negatively impacts digital transformation

3. Research methods

3.1 Data collection

This paper studies A-share listed firms in China from 2017 to 2020. The D&O insurance data came from Chinese Research Data Services (CNRDS). Digital transformation data came from annual reports of A-share listed firms. Innovation data was sourced from the INNOJOY database, while financial data and corporate governance data came from the CSMAR database and WIND database, respectively. After filtering missing values in key variables, 6,254 observations are included in the analysis. To tease out the influence of outliers, financial variables that are continuous variables are winsorized at the 1st and 99th percentiles, respectively [2].

3.2 Variable definition and model

3.2.1 D&O insurance. Following prior studies (e.g. Yuan *et al.*, 2016), we adopted a dummy variable (*D&O*) to measure D&O insurance. *D&O* equals 1 if a firm purchases D&O insurance in year *t* and 0 otherwise. We also use the term of D&O insurance to measure how many years that firms have bought D&O insurance. *LnD&OYear* is the logarithm value of 1 plus the years of D&O insurance coverage.

3.2.2 Digital transformation. Following prior research (e.g. Zhao *et al.*, 2022), we measured digital transformation by a text analysis of listed firms' annual reports. A Python tool was used to crawl the annual reports and we counted relevant words and phrases of "digital transformation", including big data technology, block chain technology and digital technology. In each category, we used a dictionary in Chinese. For example, in the digital technology category, we had fintech, digital finance, digital marketing, intelligent sales, mobile Internet and others. We then added the frequency of those words and phrases together to represent the level of digital transformation. To avoid the impact of total length of annual reports, we divided the total frequency of related words and phrases by the total number of words and phrases of the annual report (see Appendix online for more details).

3.2.3 Control variable. The control variables have three aspects: firm financial characteristics, ownership structure and characteristics of board of directors. Specifically, control variables are: firm size(*Size*), defined as the logarithm value of total asset; firm leverage(*Lev*), defined as the ratio of total liability to total asset; return on asset(*ROA*), defined as

the ratio of net profit to total asset; growth (*Growth*), defined as the growth rate of sales revenue; liquidity ratio (*Current*), defined as the ratio of current asset to current liability; size of board directors (*Board*), defined as the logarithm value of number of board directors; independent directors (*Indep*), defined as the percentage of independent directors in board; ownership concentration (*Top1*), measured as the percentage of share hold by the largest shareholder; ownership balance (*Balance*), measured by the total percentage of shares hold by the second largest to the fifth largest to the largest shareholder; dual position (*Dual*), if board of directors is the same person of CEO, it equals to one and otherwise zero; and property right (*SOE*), a dummy variable that equals to one if the firm is controlled by government agencies. We also controlled for year and industry fixed effects. The manufacturing industry code is two-digital and other industry codes are one-digital. Table 1 describes the variable definitions.

3.2.4 Model specification.

$$DT_t = \beta_0 + \beta_1 D\&O\ Insurance_t + \beta_2 Controls + \varepsilon \quad (1)$$

Model (1) is a basic model for analyzing the influence of D&O Insurance on digital transformation. *DT* is calculated according to models (1). β_1 is the coefficient of *D&O Insurance*. *D&O Insurance* is the independent variable measured by *D&O* and *LnD&OYear*. Control variables include firm size (*Size*), firm leverage (*Lev*), return on asset (*ROA*), growth opportunities (*Growth*), liquidity ratio (*Current*), size of board directors (*Board*), independent directors (*Indep*), ownership concentration (*Top1*), ownership balance (*Balance*), dual position (*Dual*) and ownership type (*SOE*). We also controlled for industry and year-fixed effects. In robust tests, firm fixed effect is also controlled.

4. Descriptive statistics and empirical results

4.1 Descriptive statistics

Table 2 reports the descriptive statistics of key variables. The mean value of digital transformation is 0.102, with a standard deviation of 0.164. To observe the coefficient of

Variable type	Variable name	Calculation method
Dependent variable	<i>DT</i>	100*(frequency of digital transformation-related words and phrases)/total words and phrases in annual reports
Independent variable	<i>D&O</i>	A dummy variable that equals 1 if a firm purchases D&O insurance in year <i>t</i> and 0 otherwise
Control variable	<i>LnD&OYear</i>	The logarithm value of 1 plus the years of D&O insurance coverage
	<i>Size</i>	The logarithm value of total asset
	<i>SOE</i>	A dummy variable that equals to one if the firm is controlled by government agencies
	<i>Lev</i>	The ratio of total liability to total asset
	<i>ROA</i>	The ratio of net profit to total asset
	<i>Growth</i>	The growth rate of sales revenue
	<i>Current</i>	The ratio of current asset to current liability
	<i>Board</i>	The logarithm value of number of board directors
	<i>Top1</i>	The percentage of share hold by the largest shareholder
	<i>Balance</i>	The total percentage of shares hold by the second largest to the fifth largest to the largest shareholder
	<i>Dual</i>	If board of directors is the same person of CEO, it equals to one and otherwise zero
	<i>Inde</i>	The percentage of independent directors in board

Table 1.
Variable definition and
description

digital transformation, we multiplied the percentage of digital transformation-related words and phrases by 100. Thus, 0.102% of annual reports are related to digital transformation on average. The mean value of *D&O* is 0.068, showing a relatively low coverage of D&O insurance; this is similar to prior studies that have investigated D&O insurance in China. On average, firms bought D&O insurance for a logarithm value of 0.110 years. The mean logarithm value of firm size (*Size*) is 22.397 and firm leverage is 0.427. Return on assets (*ROA*) has a mean value of 0.044 and the mean logarithm value of revenue growth is 0.199. The mean number of shares held by the largest shareholder is 34.6%. The percentage of independent directors (*Inde*) has a mean value of 0.375.

4.2 Baseline analysis

Table 3 presents the regression results of D&O insurance and digital transformation. The dependent variable is *DT*, representing digital transformation. Independent variables are *D&O* and *LnD&OYear*. The coefficients of *D&O* and *LnD&OYear* are significantly negative. The results show that firms that buy D&O insurance have a lower level of digital transformation. Thus, H1b is supported, indicating that D&O insurance increases D&Os' resistance to disruptive changes and negatively impacts digital transformation. There are two reasons why H1a is not supported. Firstly, D&O insurance can, theoretically, weaken corporate governance due to information asymmetry between corporations and insurers. Since insurance companies cannot unreasonably withhold consent for payment of defense and settlement costs, they settle claims even when they suspect the bad faith by directors and officers (Chung and Wynn, 2008). D&O insurance cannot effectively monitor D&Os, leading to short-term decisions and digital transformation is then excluded. Secondly, and practically, the issuers in China have not accumulated a large number of cases of D&O insurance settlements. For issuers to become effective in monitoring D&Os, issuers have to establish an experienced team, design proper insurance clauses and provide evidence for D&Os' deliberate fraud. Compared to developed economies, the monitoring role of D&O insurance in China is weak and fails to drive digital transformation.

4.3 Robustness tests

4.3.1 Control for firm fixed effects. Since the baseline results may be affected by omitting time-invariant firm-specific characteristics, we controlled for firm fixed effect in Model (1). The results are presented in Table 4. The re-estimated coefficients of the variable *D&O* are significantly negative. After controlling for firm fixed effects, D&O insurance negatively

Table 2.
Descriptive statistics

Variable	Mean	SD	Min	P10	P25	P50	P75	P90	Max
<i>DT</i>	0.102	0.164	0.000	0.011	0.025	0.055	0.120	0.234	4.360
<i>D&O</i>	0.068	0.251	0.000	0.000	0.000	0.000	0.000	0.000	1.000
<i>LnD&OYear</i>	0.110	0.465	0.000	0.000	0.000	0.000	0.000	0.000	2.398
<i>Size</i>	22.397	1.298	19.671	20.837	21.464	22.235	23.134	24.174	25.985
<i>Lev</i>	0.427	0.198	0.056	0.164	0.270	0.419	0.572	0.695	0.902
<i>ROA</i>	0.044	0.058	-0.232	0.003	0.016	0.039	0.071	0.110	0.212
<i>Growth</i>	0.199	0.428	-0.581	-0.120	0.007	0.118	0.277	0.529	2.823
<i>Board</i>	2.122	0.194	1.609	1.946	1.946	2.197	2.197	2.398	2.708
<i>Top1</i>	0.346	0.144	0.089	0.168	0.234	0.326	0.442	0.545	0.743
<i>SOE</i>	0.334	0.472	0.000	0.000	0.000	0.000	1.000	1.000	1.000
<i>Balance</i>	0.758	0.604	0.019	0.133	0.287	0.601	1.071	1.635	2.728
<i>Dual</i>	0.276	0.447	0.000	0.000	0.000	0.000	1.000	1.000	1.000
<i>Inde</i>	0.375	0.053	0.300	0.333	0.333	0.353	0.429	0.429	0.571
<i>Current</i>	2.251	2.043	0.288	0.804	1.154	1.631	2.553	4.236	15.410

Variable	(1)	(2)	Insurance and digital transformation
	<i>DT</i>		
<i>D&O</i>	−0.0115** (−2.132)		
<i>LnD&OYear</i>		−0.0075*** (−2.647)	
<i>Size</i>	0.0045** (2.516)	0.0045** (2.547)	
<i>Lev</i>	−0.0276** (−2.098)	−0.0273** (−2.072)	
<i>ROA</i>	−0.0214 (−0.537)	−0.0208 (−0.522)	
<i>Growth</i>	0.0154*** (2.929)	0.0154*** (2.927)	
<i>Board</i>	0.0423*** (2.858)	0.0423*** (2.860)	
<i>Top1</i>	−0.0289 (−1.163)	−0.0292 (−1.174)	
<i>SOE</i>	−0.0271*** (−6.712)	−0.0270*** (−6.683)	
<i>Balance</i>	−0.0037 (−0.648)	−0.0037 (−0.651)	
<i>Dual</i>	0.0130*** (2.600)	0.0130*** (2.596)	
<i>Indep</i>	0.2164*** (2.838)	0.2173*** (2.848)	
<i>Current</i>	−0.0022*** (−2.585)	−0.0022*** (−2.587)	
<i>_cons</i>	−0.1846*** (−3.355)	−0.1857*** (−3.381)	
Industry fixed effect	Yes	Yes	
Year fixed effect	Yes	Yes	
<i>N</i>	6,254	6,254	
<i>Adj.R²</i>	0.086	0.087	

Note(s): This table reports regression results of how D&O insurance influences digital transformation. Industry and year fixed effects are controlled. The independent variables are *D&O* and *LnD&OYear*. *D&O* equals one if a firm buys D&O insurance in year *t* and zero otherwise. *LnD&OYear* is the logarithm value of years that a firm has bought D&O insurance. Dependent variable is *DT*, which is measured by a percentage of digital transformation-related words and phrases. Control variables include the logarithm of total assets (*Size*), firm leverage (*Lev*), firm profitability (*ROA*), firm growth (*Growth*), board size (*Board*), largest shareholders' shares (*Top1*), ownership type (*SOE*), ownership structure (*Balance*), CEO and chairman dual position (*Dual*) and percentage of independent director (*Inde*) and current ratio (*Current*). ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

Table 3.
Baseline analysis:
D&O insurance and
digital transformation

affects digital transformation. The results in Table 4 show that baseline results are not driven by time-invariant firm-specific characteristics.

4.3.2 Propensity score matching. According to *D&O*, firms are divided into two groups according to their D&O insurance coverage. Firms that are covered by D&O insurance are divided into a treat group and the others are in a control group based on the firms' basic characteristics. The two groups are matched by a nearest neighboring matching 1:1 within the same year and industry. Panel A in Table 5 reports a balanced test of matching results. The difference of matching variables between the two groups is not significant. Take firm size in Panel A as an example: the mean value of firm size in the treat group is 23.360 and the

Variable	(1)	Digital1	(2)
<i>D&O</i>	−0.0286*** (−2.839)		
<i>LnD&OYear</i>			−0.0298** (−2.367)
<i>Size</i>	0.0083* (1.793)		0.0081* (1.753)
<i>Lev</i>	−0.0131 (−0.776)		−0.0130 (−0.769)
<i>ROA</i>	−0.0109 (−0.441)		−0.0074 (−0.301)
<i>Growth</i>	0.0015 (0.722)		0.0015 (0.758)
<i>Board</i>	0.0072 (0.530)		0.0081 (0.599)
<i>Top1</i>	−0.0554* (−1.715)		−0.0620* (−1.927)
<i>SOE</i>	0.0190* (1.747)		0.0189* (1.737)
<i>Balance</i>	−0.0024 (−0.357)		−0.0036 (−0.550)
<i>Dual</i>	−0.0003 (−0.067)		−0.0003 (−0.069)
<i>Indep</i>	−0.0087 (−0.233)		−0.0036 (−0.095)
<i>Current</i>	0.0000 (0.040)		−0.0001 (−0.071)
<i>_cons</i>	−0.0204*** (−3.933)		−0.0207*** (−3.984)
Firm fixed effect	Yes		Yes
Year fixed effect	Yes		Yes
<i>N</i>	6,254		6,254
<i>Adj.R²</i>	0.035		0.034

Table 4.
Firm fixed effects:
D&O insurance and
digital transformation

Note(s): This table reports results of how D&O insurance influences digital transformation after controlling for firm fixed effects. Firm and year fixed effects are controlled. The independent, dependent and control variables are the same as those in Table 3. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

mean firm size in the other group is 23.320. The *T* value for the two is −0.290. The balanced test shows that there are no significant differences between the treat group and the control group in terms of matching variables. Based on the matched sample, the baseline model for testing D&O insurance and digital transformation is re-estimated. Panel B of Table 5 reports the re-estimated results of baseline model. The coefficients of independent variable *D&O* and *LnD&OYear* are significantly negative. Columns (1) and (2) in Panel B support that D&O insurance hampers digital transformation.

4.3.3 Alternative measure of digital transformation. When calculating digital transformation, several categories are included, such as big data and block chain. To mitigate problems caused by digital transformation dictionary, we separately calculated big data, block chain and application of digital technology, represented by DT1, DT2 and DT3 respectively. The results remain robust in Table 6.

4.3.4 Control for equity incentive plan. Equity incentive is also part of incentive scheme. D&Os' interests are tied with shareholders' when D&Os hold some percentage of stock shares. Therefore, we further control for the influence of equity incentives. The data is from

Panel A balanced test Variable	Treated	Control	<i>T</i> value	<i>p</i> value
<i>Size</i>	23.360	23.320	0.210	0.830
<i>Lev</i>	0.513	0.499	0.740	0.462
<i>ROA</i>	0.0363	0.0357	0.120	0.901
<i>Growth</i>	0.215	0.176	0.900	0.369
<i>Board</i>	2.167	2.165	0.100	0.919
<i>Top1</i>	0.365	0.367	−0.120	0.901
<i>SOE</i>	0.606	0.593	0.290	0.769
<i>Balance</i>	0.772	0.737	0.640	0.523
<i>Dual</i>	0.144	0.139	0.140	0.890
<i>Indep</i>	0.380	0.386	−1.050	0.296
<i>Current</i>	1.755	1.804	−0.310	0.760

Panel B matched sample: D&O insurance and digital transformation

Variable	(1)	<i>DT</i>	(2)
<i>D&O</i>	−0.0220** (−2.148)		
<i>LnD&OYear</i>			−0.0120** (−2.508)
<i>Size</i>	−0.0083 (−1.361)		−0.0076 (−1.251)
<i>Lev</i>	−0.0118 (−0.305)		−0.0088 (−0.225)
<i>ROA</i>	−0.0032 (−0.020)		0.0076 (0.048)
<i>Growth</i>	0.0078 (0.816)		0.0074 (0.755)
<i>Board</i>	−0.0085 (−0.319)		−0.0078 (−0.288)
<i>Top1</i>	0.1272** (2.544)		0.1233** (2.466)
<i>SOE</i>	−0.0523*** (−3.973)		−0.0504*** (−3.918)
<i>Balance</i>	0.0629*** (3.588)		0.0621*** (3.533)
<i>Dual</i>	0.0247 (1.469)		0.0235 (1.412)
<i>Indep</i>	0.0610 (0.613)		0.0799 (0.794)
<i>Current</i>	−0.0034 (−1.110)		−0.0039 (−1.267)
<i>_cons</i>	0.2380* (1.962)		0.2116* (1.772)
<i>N</i>	340		340
<i>Adj.R</i> ²	0.194		0.195

Note(s): This table reports the balanced test for propensity score matching in Panel A and results of how D&O insurance influences digital transformation within matched-sample in Panel B. The independent, dependent and control variables are the same as those in Table 3. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

Table 5.
Propensity score
matching method

WIND database. *EquityIncentive* is defined as a dummy variable that equals to one from the year that firms announced an equity incentive plan to following validating years. Otherwise,

it equals to zero. In Table 7, the coefficient of *EquityIncentive* is significantly positive while the coefficient of D&O insurance remains significantly negative. The results indicate that equity incentive may be a more effective way to motivate digital transformation.

4.3.5 Exclusion of reverse causality. Another potential challenge to the conclusions is that companies may change their D&O insurance purchase decisions in preparation for digital transformation, creating a reverse causality problem. Following the approach of Jiang *et al.* (2016), we defined Model (2) to exclude the possibility of reverse causality. In Model (2), the dependent variable is mainly the difference term of *D&O Insurance* in Model (1), and the independent variable is the digital transformation degree *DT* of the enterprise in the future period (the next period and the second next period, respectively). If the coefficient β_1 in model (2) is not significant, it indicates that enterprises will not significantly change their tendency to purchase D&O Insurance in the preparation stage of digital transformation.

$$\Delta D\&O\ Insurance_t = \beta_0 + \beta_1 DT_{t+1}(DT_{t+2}) + \beta_2 Controls + \epsilon \quad (2)$$

In Table 8, the coefficient of DT_{t+1} and DT_{t+2} is not significant, indicating that enterprises are unlikely to change the decision of D&O insurance in the process of preparing for digital transformation. Therefore, the conclusions of this paper are unlikely to be driven by reverse causality.

5. Additional analysis

5.1 Do firms with worse internal governance also embrace digital transformation?

As stated above, digital transformation requires substantial a shift of the entire organization. Firms with better internal governance are motivated to respond quickly to customers and reduce costs to compete in the market. Therefore, the company's internal governance may reduce the negative impact of D&O insurance on digital transformation. To investigate whether internal governance affects the relationship between D&O insurance and digital transformation, we define a proxy variable of corporate governance, *IC_defects*, which takes the value of 1 when the firms have audited internal control defects and 0 in other cases. We summarize two interaction terms: *D&O* IC_defects* and *LnD&OYear * IC_defects*. The results are shown in Table 9. The coefficient of the interaction terms is significantly negative, indicating that worse internal governance has significantly intensified the negative impact of D&O insurance's digital transformation.

5.2 Can state ownership eliminate our finding?

State-owned enterprises (SOEs) are naturally different from non-SOEs since SOEs have both economic and non-economic aims, such as stable employment and support regional development. Thus, SOEs are not likely to invest in risky projects (Dong *et al.*, 2014). Executives in SOEs also have political objectives. For the pursuit of political ranks, executives are unwilling to undertake risks (Zhang *et al.*, 2021). For digital transformation to succeed, engaged managers and risk-taking are important factors. Thus, the relationship between D&O insurance and digital transformation in SOEs is stronger. In Table 10, the coefficients of *D&O*SOE* and *LnD&OYear*SOE* are positive and coefficients of interactive items are negative. The results show that D&O Insurance reduces digital transformation to a large extent in SOEs.

6. Mechanism identification

Technological innovation is a tool for achieving digital transformation, but also for updating knowledge base, providing a change-oriented culture, flexible structure and entrepreneur mindsets. D&O insurance can deter digital transformation through explorative innovation.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
<i>D&O</i>	-0.0012* (-1.673)		-0.0004*** (-2.749)		-0.0001* (-1.939)	-0.0001** (-2.348)
<i>LnD&OYear</i>		-0.0009*** (-3.796)		-0.0002** (-2.499)		0.0000*
<i>Size</i>	0.0011*** (5.202)	0.0011*** (5.221)	0.0003*** (3.382)	0.0003*** (3.362)	0.0000*	0.0000*
<i>Lev</i>	-0.00048** (-2.349)	-0.00047** (-2.330)	-0.0004 (-0.553)	-0.0003 (-0.540)	-0.0002* (-1.853)	-0.0002* (-1.828)
<i>ROA</i>	-0.0117*** (-2.676)	-0.0116*** (-2.667)	-0.0027 (-1.625)	-0.0026 (-1.607)	-0.0001 (-0.187)	-0.0001 (-0.174)
<i>Growth</i>	0.0019*** (2.646)	0.0019*** (2.645)	-0.0000 (-0.190)	-0.0000 (-0.191)	0.0001*** (2.719)	0.0001*** (2.717)
<i>Board</i>	0.0013 (1.069)	0.0013 (1.078)	-0.0011* (-1.857)	-0.0011* (-1.863)	0.0004*** (2.976)	0.0004*** (2.978)
<i>Top1</i>	-0.0042** (-2.140)	-0.0042** (-2.147)	0.0004 (0.539)	0.0004 (0.511)	-0.0003 (-1.041)	-0.0003 (-1.051)
<i>SOE</i>	-0.0024*** (-4.881)	-0.0024*** (-4.890)	-0.0001 (-0.672)	-0.0001 (-0.695)	-0.0002*** (-6.444)	-0.0002*** (-6.413)
<i>Balance</i>	-0.0007 (-1.453)	-0.0007 (-1.448)	0.0004* (1.690)	0.0004* (1.672)	-0.0000 (-0.606)	-0.0000 (-0.610)
<i>Dual</i>	0.0007 (1.323)	0.0007 (1.310)	0.0003 (1.394)	0.0003 (1.401)	0.0001** (2.528)	0.0001** (2.524)
<i>Indep</i>	0.0040 (0.839)	0.0042 (0.878)	-0.0011 (-0.796)	-0.0011 (-0.810)	0.0021*** (2.882)	0.0021*** (2.890)
<i>Current</i>	-0.0001 (-0.542)	-0.0001 (-0.535)	0.0001 (1.618)	0.0001 (1.610)	-0.0000*** (-2.844)	-0.0000*** (-2.844)
<i>_cons</i>	-0.0204*** (-3.933)	-0.0207*** (-3.984)	-0.0041** (-2.303)	-0.0040** (-2.258)	-0.0016*** (-3.059)	-0.0016*** (-3.081)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	6,254	6,254	6,254	6,254	6,254	6,254
<i>Adj.R²</i>	0.064	0.064	0.027	0.027	0.083	0.083

Note(s): This table reports results of how D&O insurance influences digital transformation when digital transformation is measured by alternative proxies. In column (1) and (2), digital transformation is measured by percentage big data-related words and phrase. In column (3) and (4), digital transformation is measured by percentage block chain-related words and phrase. In column (5) and (6), digital transformation is measured by percentage digital technology application-related words and phrase. The independent and control variables are the same as those in Table 3. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

Table 6.
Alternative measure of
digital transformation

Variable	(1)	<i>DT</i>	(2)
<i>D&O</i>	−0.0109** (−2.020)		
<i>LnD&OYear</i>			−0.0070** (−2.491)
<i>EquityIncentive</i>	0.0256*** (3.661)		0.0255*** (3.648)
<i>Size</i>	0.0046** (2.575)		0.0046*** (2.602)
<i>Lev</i>	−0.0313** (−2.366)		−0.0309** (−2.341)
<i>ROA</i>	−0.0411 (−1.036)		−0.0405 (−1.020)
<i>Growth</i>	0.0152*** (2.873)		0.0152*** (2.871)
<i>Board</i>	0.0417*** (2.837)		0.0417*** (2.839)
<i>Top1</i>	−0.0267 (−1.078)		−0.0270 (−1.090)
<i>SOE</i>	−0.0235*** (−5.523)		−0.0233*** (−5.503)
<i>Balance</i>	−0.0036 (−0.634)		−0.0036 (−0.639)
<i>Dual</i>	0.0126** (2.518)		0.0126** (2.515)
<i>Indep</i>	0.2105*** (2.786)		0.2113*** (2.795)
<i>Current</i>	−0.0022*** (−2.596)		−0.0022*** (−2.598)
<i>_cons</i>	−0.1840*** (−3.358)		−0.1849*** (−3.381)
Industry fixed effect	Yes		Yes
Year fixed effect	Yes		Yes
<i>N</i>	6,254		6,254
<i>Adj.R²</i>	0.090		0.090

Note(s): This table reports results of how D&O insurance influences digital transformation after controlling for other incentive plan. Industry and year fixed effects are controlled. The independent and dependent are the same as those in Table 3. Additional control variable is *EquityIncentive*, which equals to one from the year that firms announced an equity incentive plan to following validating years. Otherwise, it equals to zero. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

Table 7.
Control for equity
incentive plan

Innovations differ in terms of exploration, risks, duration, etc. The explorative VS exploitative innovation strategy is a widely used conceptual framework (Jia, 2018; Wang et al., 2017). Firms that conduct explorative innovations explore in new technological fields and create new knowledge. By contrast, firms that focus on exploitative innovation remain in prior technology trajectories without stepping into new ones. Explorative innovations have proven to demand higher amount of investment and longer duration and are accompanied by higher risks in terms of choosing bad projects, technology exploration and project management. However, explorative innovations determine the technological peak that a firm can reach, renew previous knowledge, expand technology boundaries and enhance long-term competence (Amara and Landry, 2005; Forés and Camisón, 2016). In the context of the

Variable	(1)	(2)	(3)	(4)	Insurance and digital transformation
	$\Delta D\&O$		$\Delta LnD\&OYear$		
DT_{t+1}	0.0154 (1.3527)		-0.0034 (-0.3929)		<div>193</div>
DT_{t+2}		0.0010 (0.0658)		-0.0037 (-0.4786)	
<i>Size</i>	0.0024 (1.3303)	0.0046* (1.7714)	0.0055*** (4.0659)	0.0056*** (4.2378)	
<i>Lev</i>	0.0135 (0.9568)	0.0101 (0.5036)	-0.0021 (-0.1934)	0.0013 (0.1222)	
<i>ROA</i>	-0.0626* (-1.8822)	-0.0414 (-0.7456)	-0.0094 (-0.3681)	-0.0547* (-1.9156)	
<i>Growth</i>	0.0077* (1.8931)	0.0207*** (3.8391)	-0.0001 (-0.0444)	-0.0004 (-0.1367)	
<i>Board</i>	-0.0034 (-0.3128)	-0.0160 (-1.0051)	0.0063 (0.7520)	0.0068 (0.8288)	
<i>Top1</i>	0.0236 (1.4156)	-0.0148 (-0.6213)	0.0414*** (3.2434)	0.0466*** (3.8017)	
<i>SOE</i>	0.0056 (1.4158)	0.0156*** (2.7405)	0.0082*** (2.7044)	0.0056* (1.9257)	
<i>Balance</i>	0.0073* (1.8491)	-0.0041 (-0.7335)	0.0099*** (3.2768)	0.0099*** (3.4440)	
<i>Dual</i>	-0.0036 (-0.9149)	0.0018 (0.3163)	-0.0048 (-1.6141)	-0.0033 (-1.1545)	
<i>Indep</i>	-0.0067 (-0.1767)	-0.0792 (-1.4341)	0.0625** (2.1577)	0.0580** (2.0453)	
<i>Current</i>	0.0014 (1.2280)	0.0035** (2.1527)	0.0021** (2.3278)	0.0026*** (3.1633)	
<i>_cons</i>	-0.0648 (-1.4204)	-0.0519 (-0.7943)	-0.1843*** (-5.2878)	-0.1911*** (-5.6919)	
Industry fixed effect	Yes	Yes	Yes	Yes	
Year fixed effect	Yes	Yes	Yes	Yes	
<i>N</i>	3,668	1,676	3,668	1,676	
<i>Adj.R²</i>	0.0046	0.0147	0.0190	0.0421	

Note(s): This table reports results of whether the preparation of digital transformation influences D&O insurance. Industry and year fixed effects are controlled. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

Table 8. Exclusion of reverse causality

Chinese economy, encouraged by innovation-promoting policies, firms have a large quantity of innovations in order to gain tax reduction and government subsidy. The coverage of D&O insurance can lead to unintended moral hazard, so D&Os are likely to adopt an exploitative innovation strategy, leading to familiarity traps and a culture that is reluctant to change. Exploitative innovation not only reduces technical support for digital transformation, but also leads to a risk-averse and reluctant-to-change culture. On the contrary, explorative innovation drives digital transformation by providing an innovation push and culture support.

We collected patent information from the INNOJOY database [3]. Each patent has information in the form of a unique identification code, abstract, applicants, inventors, technological classifications, backward citations, etc. Based on patent data, innovation quantity is measured by *Patentnumber*, which is the number of patents that a firm holds in a certain year. We also constructed three measures of explorative innovation. The first measure is constructed using backward citation. Backward citations that a patent receives can signal its value. The more a patent is cited by other patents, the larger its technological significance.

Variable	(1)	<i>DT</i>	(2)
<i>D&O</i>	−0.0050 (−0.6684)		
<i>LnD&OYear</i>			−0.0049 (−1.3926)
<i>D&O* IC_defects</i>	−0.0208** (−2.3355)		
<i>LnD&OYear* IC_defects</i>			−0.0141*** (−3.1371)
<i>IC_defects</i>	−0.0007 (−0.1741)		−0.0013 (−0.3041)
<i>Size</i>	0.0046** (2.5750)		0.0047*** (2.6494)
<i>Lev</i>	−0.0278** (−2.1105)		−0.0275** (−2.0874)
<i>ROA</i>	−0.0224 (−0.5611)		−0.0213 (−0.5354)
<i>Growth</i>	0.0154*** (2.9169)		0.0154*** (2.9095)
<i>Board</i>	0.0426*** (2.8585)		0.0427*** (2.8631)
<i>Top1</i>	−0.0280 (−1.1304)		−0.0274 (−1.1047)
<i>SOE</i>	−0.0269*** (−6.4412)		−0.0266*** (−6.3648)
<i>Balance</i>	−0.0036 (−0.6358)		−0.0035 (−0.6135)
<i>Dual</i>	0.0130*** (2.6125)		0.0130*** (2.6120)
<i>Indep</i>	0.2166*** (2.8364)		0.2176*** (2.8477)
<i>Current</i>	−0.0021** (−2.5400)		−0.0021** (−2.5714)
_cons	−0.1881*** (−3.3370)		−0.1914*** (−3.3961)
Industry fixed effect	Yes		Yes
Year fixed effect	Yes		Yes
<i>N</i>	6,254		6,254
<i>Adj.R</i> ²	0.0816		0.0819

Table 9.
Heterogeneity test:
Internal governance

Note(s): This table reports moderating role of internal governance. Industry and year fixed effects are controlled. The independent, dependent and control variables are the same as those in Table 4. *D&O*IC_defects* and *LnD&OYear* IC_defects* are interactive items. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively

An innovation that influences future technology is a vital feature of explorative innovation (Citation) (Wang *et al.*, 2017). The second measure is *Patent_in_Newclass*, which is the number of patents that a firm owns in newly entered technology field. If a firm enters a new technology field, it is exploring unfamiliar technology and creating new knowledge. Technologies decay over time and the knowledge base will decrease without renewing. We also use the number of newly entered technological field (*NewClass*) as a measure of explorative innovation (Balsmeier *et al.*, 2016).

In Panel A of Table 11, column (1) of the mechanism test shows that a dummy variable of D&O insurance does not significantly influence the number of patents. In column (2), the

Variable	(1)	DT	(2)	Insurance and digital transformation
<i>D&O</i>	0.0142 (1.189)			
<i>LnD&OYear</i>			0.0079 (1.107)	
<i>D&O*SOE</i>	−0.0376*** (−2.933)			
<i>LnD&OYear*SOE</i>			−0.0209*** (−2.795)	
<i>SOE</i>	−0.0209*** (−4.720)		−0.0211*** (−4.808)	
<i>Size</i>	0.0047*** (2.624)		0.0046*** (2.623)	
<i>Lev</i>	−0.0319** (−2.411)		−0.0311** (−2.347)	
<i>ROA</i>	−0.0396 (−1.003)		−0.0399 (−1.009)	
<i>Growth</i>	0.0152*** (2.874)		0.0151*** (2.854)	
<i>Board</i>	0.0410*** (2.790)		0.0413*** (2.810)	
<i>Top1</i>	−0.0250 (−1.008)		−0.0249 (−1.005)	
<i>Balance</i>	−0.0032 (−0.555)		−0.0031 (−0.538)	
<i>Dual</i>	0.0130*** (2.595)		0.0130*** (2.598)	
<i>Indep</i>	0.2106*** (2.789)		0.2125*** (2.812)	
<i>Current</i>	−0.0022*** (−2.588)		−0.0022*** (−2.586)	
<i>EquityIncentive</i>	0.0259*** (3.701)		0.0259*** (3.698)	
<i>_cons</i>	−0.1840*** (−3.358)		−0.1849*** (−3.381)	
Industry fixed effect	Yes		Yes	
Year fixed effect	Yes		Yes	
<i>N</i>	6,254		6,254	
<i>Adj.R²</i>	0.090		0.090	

Note(s): This table reports moderating role of ownership type. Industry and year fixed effects are controlled. The independent, dependent and control variables are the same as those in Table 4. *D&O*SOE* and *LnD&OYear*SOE* are interactive items. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

Table 10.
Heterogeneity test:
State ownership

coefficient of *LnD&OYear* is also not significant. Columns (1) and (2) show that D&O insurance does not reduce the number of innovations. As Columns (3) to (8) in Panel A of Table 11 show, coefficient of the dummy variable of D&O insurance is not significant. However, the coefficients of *LnD&OYear* from Columns (3) to (8) are significantly negative. The results indicate that the longer D&Os are covered by D&O insurance, the lower the extent of explorative innovation. The coefficient of D&O is not significant, showing that buying D&O insurance does not reduce innovation within a short time. This is probably because explorative innovation requires a long duration. Panel B of Table 10 presents the relationship between firm innovation and digital transformation. Both innovation quantity and explorative innovation strategy promote digital

Table 11.
Mechanism
identification

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>Patentnumber</i>		<i>Citation</i>		<i>Patent_in_Newclass</i>			
<i>D&O</i>	-0.0020 (-0.020)		-0.1045 (-0.950)		-0.0178 (-0.520)		-0.0217 (-0.850)	
<i>LnD&OYear</i>		-0.0849 (-1.490)		-0.1310** (-2.200)		-0.0334* (-1.870)		-0.0247* (-1.800)
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	9,206	9,206	9,206	9,206	9,206	9,206	9,206	9,206
<i>Adj. R²</i>	0.0499	0.0501	0.0374	0.0378	0.0196	0.0203	0.0207	0.0209
Panel B: Innovation and digital transformation								
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>DT</i>		<i>DT</i>		<i>DT</i>		<i>DT</i>	
<i>Patentnumber</i>	0.0030*** (4.230)	0.0029*** (4.190)						
<i>Citation</i>			0.0017** (2.600)	0.0017** (2.570)	0.0114*** (5.280)	0.0115*** (5.190)		
<i>Patent_in_Newclass</i>								
<i>NewClass</i>							0.0145*** (5.010)	0.0144*** (4.980)
<i>Sobel Z</i>	0.0175	1.405	0.910	1.687	0.538	1.782	0.861	1.718
<i>b Value</i>	0.986	0.160	0.363	0.092	0.590	0.075	0.389	0.0857
<i>Controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	9,206	9,206	9,206	9,206	9,206	9,206	9,206	9,206
<i>Adj. R²</i>	0.0185	0.0189	0.0174	0.0177	0.0197	0.0199	0.0194	0.0197

Note(s): This table reports mediating role of firm innovation between D&O insurance and digital transformation. Industry and year fixed effects are controlled. In panel A, the dependent variables are firm innovation. In column (1) and (2), *Patentnumber* is the logarithm number of patents that a firm holds in year *t*. In column (3) and (4), *Citation* is the logarithm number of citations that a firm receives for patents that it holds in year *t*. In column (5) and (6), *Patent_in_Newclass* is the logarithm number of patents that are in newly entered technological fields in year *t*. In column (7) and (8), *NewClass* is the logarithm number of newly entered technological fields that a firm enters in year *t*. The independent variables are the same in Table 4. In panel B, the dependent variable is digital transformation. The independent variable is *Patentnumber*, *Citation*, *Patent_in_Newclass* and *NewClass*. Control variables are the same as those in Table 4. ***, **, * indicate significance at the 1, 5 and 10% levels, respectively

transformation. Sobel tests have a Z value supporting that the long time of D&O insurance negatively influences explorative innovation and then negatively influences digital transformation. The mechanism test shows that D&O insurance negatively influences digital transformation through hampering explorative innovation.

7. Conclusion

Early research on digital transformation focused on the technical part, while scholars have recently found that work force, especially the role of D&Os, is critical for the success of digital transformation. Digital transformation requires a fundamental shift of strategy, business model, organizational structures, people, mindset and leadership. The rather disruptive and risky process requires substantial management engagement. Even though the demand for D&O insurance is increasing, the governance role of D&O insurance is still under discussion. Motivated by the need to fill the gap between executive incentive scheme and digital transformation in emerging markets, we empirically investigated the influence of D&O insurance on digital transformation. Our findings show that D&O insurance coverage negatively affects digital transformation and the longer D&O insurance is bought, the lower level of digital transformation is. Further, we found that D&O insurance reduces explorative innovation instead of innovation quantity, which shows managerial myopia caused by D&O insurance. Sobel tests further indicate that D&O insurance hampers digital transformation through reducing explorative innovation. Digital transformation requires not only technology support, but also non-tech aspects, such as culture, D&Os' engagement and willing-to-change mindset. D&O insurance leads to a low level of explorative innovation and a risk-averse culture. If D&Os are covered by D&O insurance for the long term, they are less likely to undertake risky projects. Thus, D&O insurance negatively influences digital transformation. In heterogeneity tests, firms with weak internal governance and SOEs are negatively influenced of D&O insurance to a large extent.

Theoretically, the results enrich the governance weakening of D&O insurance. D&O insurance reduces directors' and officers' costs in defending and settling lawsuits. Under the coverage of D&O insurance, costs of directors and officer's opportunistic behavior are compensated and then D&O insurance can lead to an unintended moral hazard problem, which hampers digital transformation. This paper also provides practical insights. Firstly, from a non-tech perspective, providing insurance for D&Os is not an effective way of achieving digital transformation. For the success of digital transformation in achieving organizational goals, firms need to establish strong governance to avoid D&Os' opportunistic behaviors, especially for SOEs. Secondly, as the results indicate, D&O insurance negatively influence digital transformation. D&O insurance fails to strengthen internal governance and reduce moral hazard problem raises. For D&O insurance to effectively reduce unintended moral hazard problem, insurers need to monitor the behavior of D&Os to identify deliberate frauds. As the demand of D&O insurance is increasing, the insurers should be well-prepared to establish experienced team and design proper insurance clauses. Overall, our evidence is consistent with the notion that D&O insurance causes unintended moral hazard and increases risk aversion. This paper sheds light on whether digital transformation can be triggered by executive incentive scheme. The findings are expected to add to the debate on D&O insurance, shed insights into the triggers of digital transformation and provide evidence for practitioners.

Notes

1. Based on questions and replies on an interactive platform that is established by Shanghai Stock Exchange, we summarized digital transformation-related questions and replies.

2. Chinese Research Data Services (CNRDS) is a high-quality, open and integrated data platform for China's economic, financial and business research (e.g. [Chen et al., 2020](#); [Li et al., 2022](#)). China Stock Market Accounting Research (CSMAR) database. CSMAR is a series of financial and economic databases, including stock market, listed companies, fund market, bond market, derivative products, economic research, overseas research and special topics, and each series contains corresponding databases ([Wang et al., 2022](#); [Yang et al., 2021](#)). We also collected financial data from the WIND database, which includes data and information on stocks, bonds, futures, foreign exchange, funds, indexes, warrants, macro industries, and other varieties ([Boeing, 2016](#)).
3. Dawek Innojoy Patent Database (here after INNOJOY) is a patent information comprehensive application platform that integrates global patent data retrieval, analysis, management and transformation. It is widely used in patent related researches ([Yin and Tao, 2018](#)).

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Appendix

The supplementary material for this article can be found online.

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