

Directors' and Officers' Liability Insurance and the Digital Transformation of Enterprises: Based on the Empirical Evidence of Listed Companies in China from 2011 to 2021

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Abstract. Amidst the wave of the digital economy, numerous enterprises have commenced the process of digital transformation to address market challenges and fluctuations, as well as to pursue sustainable growth. Directors' and officers' liability insurance (D&O insurance), being an essential instrument of corporate governance, necessitates an empirical investigation to unravel its influence on enterprises' digital transformation. This study selects Shanghai-Shenzhen A-share listed companies from 2011 to 2021 as research subjects to examine the impact of D&O insurance procurement on enterprises' digital transformation and its underlying mechanisms. The findings reveal that the procurement of D&O insurance significantly fosters the progress of enterprise digital transformation, and this conclusion remains robust after employing a series of robustness tests, including the instrumental variable method and DIGT. The mechanism analysis indicates that by elevating the risk-bearing capacity of enterprise managers, the management efficiency of enterprises can be enhanced, thereby motivating supervisory executives to augment the quality of internal control and facilitate the digital transformation of enterprises. Further examination discloses that executive equity incentives and executive responsibility insurance possess complementary effects in promoting enterprise digital transformation, making the subscription of executive responsibility insurance a pivotal factor in enhancing the effectiveness of enterprise digital transformation and fostering high-quality economic development.

Keywords: Directors' and officers' liability insurance, The digital transformation of enterprises, Baseline regression, Robust analysis, Endogeneity test.

1. Introduction

The report submitted to the 20th National Congress of the Communist Party of China emphasized the necessity to expedite the growth of the digital economy and facilitate the profound integration of the digital and real economies. The 14th Five-Year Plan for the Development of Digital Economy issued by the State Council also urged the vigorous promotion of the digital transformation of industries and the empowerment of the transformation and upgrading of traditional industries. These demands indicate that the digital economy has emerged as a vital driving force for constructing a new development paradigm and fostering high-quality economic growth. According to the White Paper on the Digital Transformation and Development of Chinese Enterprises (2023), the aggregate scale of China's digital economy has escalated year by year from 2016 to 2022, amounting to 50.2 trillion yuan in 2022, a year-on-year increase of 10.3%, and is projected to reach 70.8 trillion yuan in 2025. An increasing number of enterprises are embracing the digital transformation wave, and the proportion of Chinese enterprises with significant digital transformation achievements has soared from 7 percent in 2018 to 17 percent in 2022. In essence, enterprise digital transformation pertains to the information technology and organizational modifications involved in digital-driven strategic business transformation, encompassing personnel and finance, input-output, knowledge and capabilities, and corporate culture. At present, existing research on digital transformation primarily focuses on three aspects. First, it emphasizes the specific process and orientation of enterprise digital transformation. Digital transformation is the result of internal and external environmental factors, which has a considerable impact on the production process and management process of enterprises [1]. Second, it revolves around the value effect and performance outcomes subsequent to the digital

transformation of enterprises. Some scholars have examined the implications of enterprise digital transformation from the perspectives of enterprise behavior, organizational structure [3], and enterprise performance [8]. Finally, it zeroes in on the factors that influence enterprises' implementation of digital transformation. Furthermore, digital transformation is a high-risk activity typified by high costs, protracted pain periods, and significant externalities. Corporate executives tend to be risk-averse and short-sighted due to considerations related to job promotion, equity incentives, and reputation. According to Accenture's survey of 570 enterprises in China in 2022, over 40% of the executives interviewed stated that they do not intend to increase investment in digital transformation in the next one to two years. Consequently, finding ways to stimulate the transformation of business executives and encourage many enterprises that are hesitant or in a wait-and-see mode to take the initiative to transform has become the linchpin to improve the effectiveness of digital transformation and foster high-quality economic development.

The term directors' and officers' liability insurance refers to the insurance company that compensates for the legal costs and other corresponding civil liabilities when directors, supervisors, and senior executives are held accountable for negligence or misconduct while performing their duties. Currently, the governance effects of D&O insurance on listed companies primarily encompass the management incentive hypothesis, external supervision hypothesis, and moral hazard hypothesis. Among the various hypotheses, the Management Incentive Hypothesis and External Supervision Hypothesis highlight the positive impact of D&O insurance on companies, suggesting that such insurance not only motivates listed company managers to actively perform their duties and exhibit diligence and progressiveness but also serves as an external supervisor to reduce corporate agency costs. The Moral Hazard Hypothesis, on the other hand, emphasizes that D&O insurance for listed companies transfers the risks associated with management's actions and decisions to insurance companies, thereby reducing the self-interested costs of management and fostering moral hazard and opportunistic behaviors. First, the introduction of D&O insurance shifts managers' operational risks to insurance companies, mitigating their operational risks and reducing managers' risk aversion tendencies. This encourages them to be proactive in pursuing the goal of maximizing enterprise value by investing in entities and innovative projects that contribute to the long-term development of companies. Second, the "risk cover" provided by D&O insurance for managers weakens the deterrent effect of law, stimulating managers' motivation to seek personal gains. This, in turn, leads to moral hazard and increases profit-seeking investment decisions. Therefore, whether D&O insurance effectively utilizes its incentive and supervision functions, curbs the risk avoidance tendency of management, and strengthens management's willingness to undergo digital transformation or fosters "over-protection" for management and encourages opportunistic behavior under self-interest motives, thereby hindering digital transformation, merits further exploration.

As enterprise digital transformation demonstrates a positive moderating influence on the correlation between management power and high-quality corporate development [9], and management power has a positive correlation with D&O insurance [10], the latter can potentially enhance the high-quality growth of enterprises. Consequently, it becomes imperative to examine the moderating effect of enterprise digital transformation on the impact of D&O insurance on management power and high-quality corporate development. D&O insurance can facilitate high-quality corporate development by fostering innovation and minimizing agency costs. Furthermore, enterprise digital transformation can stimulate management [11], while internal control can influence the adaptability of strategic decisions, as well as the speed and severity of destruction, all of which are closely associated with high-quality corporate development. Existing research primarily emphasizes the significance of enterprises' digital transformation capabilities, resources, and paths, yet insufficiently addresses the prerequisite of executive transformation willingness. In other words, exploring how to facilitate transformation when executives possess adequate incentives becomes a practical necessity, which also serves as the logical foundation of this study. Digital transformation, akin to innovation, is a high-risk activity. If suitable risk hedging measures or risk dispersion instruments can be identified, it would undoubtedly enhance managers' risk tolerance and encourage

their engagement in digital transformation. In recent years, D&O insurance, which has experienced a surge in the domestic capital market, serves as an ideal tool for dispersing managers' practice risk and mitigating the loss of decision-making risk. Considering the above, this study examines the impact and mechanism of Directors' and Officers' (D&O) insurance subscription on the digital transformation of companies listed on the Shanghai and Shenzhen A-share markets from 2011 to 2021. The findings reveal that the subscription of D&O insurance promotes overall digital transformation in enterprises, and this conclusion remains valid following a series of robustness and endogeneity tests. Additionally, the research indicates that under high-risk external conditions, private ownership, and severe short-sighted executive behavior, the subscription of D&O insurance has an even more pronounced positive influence on enterprise digital transformation. Lastly, the subscription of directors' responsibility insurance can enhance enterprises' total factor productivity by facilitating their digital transformation.

The primary contributions of this paper are summarized as follows. First, from the perspective of D&O insurance subscription, the research on the influencing factors of enterprise digital transformation is expanded. The effectiveness of enterprise digital transformation primarily depends on the strength of executive transformation incentives, an aspect that has hitherto received insufficient attention in existing studies. From the perspective of corporate subscription of directors' liability insurance, this study demonstrates that directors' liability insurance can serve as an incentive and a supervisory mechanism to facilitate enterprises' digital transformation, thereby expanding the research on the driving factors of digital transformation. Furthermore, it enhances the economic significance of corporate subscription of D&O insurance. While existing literature has focused on the impact of D&O insurance on enterprise value, independent innovation, and foreign investment levels, no discussions have been held on the role of digital transformation, a high-risk activity in the context of the digital economy. This study underscores the significance of D&O insurance in promoting enterprises' digital transformation. Additionally, the study confirms that D&O insurance generally promotes enterprise digital transformation, supporting the management incentive hypothesis of D&O insurance, but not the moral hazard hypothesis, thereby enriching the empirical evidence for the incentive hypothesis of D&O insurance.

2. Literature review and theoretical mechanism

2.1. Literature review

Initially developed in the 1930s in the United States, D&O insurance came into existence following the Great Depression. With growing calls for intensified oversight of the securities market and enhanced investor protection, the accountability of directors and supervisors was incorporated into federal securities law. This led to a sudden increase in the professional risks faced by directors and supervisors of listed companies. Against this backdrop, D&O insurance was created and rapidly evolved. Nowadays, the insurance coverage rate for D&O insurance in the United States, Canada, Singapore, and Hong Kong, China has exceeded 80%. Despite its widespread use in the developed capital market, the economic implications and governance effects of D&O insurance continue to be the subject of extensive debate in the academic world. Three main viewpoints have emerged, including the management incentive hypothesis, external supervision hypothesis, and moral hazard hypothesis.

The management incentive hypothesis posits that within the framework of principal-agent analysis, corporate executives act as rational economic individuals pursuing higher salaries, better reputations, and faster promotions. When faced with investment projects exhibiting "high risk and high return" characteristics, executives tend to be risk-averse, avoiding decision-making errors that could result in substantial losses. As a management tool for dispersing executives' practice risks, D&O insurance can cover decision-making risk losses and mitigate their risk-averse tendencies. This enables them to be more diligent when confronted with projects with high uncertainty but that are beneficial to the company's development and shareholders' interests. Consequently, enterprises can reduce agency costs. For instance, Hu Guoliu and Hu Jun (2014) discovered that the subscription of D&O insurance

can exert an incentive effect and enhance enterprise value. Chen Hong et al. (2021) also noted that D&O insurance can mitigate the career concerns of management in OFDI, boost their risk incentives, and elevate the scale of OFDI.

The external supervision hypothesis highlights the role of external supervision executed by insurance companies and its impact on enhancing corporate governance. This is attributed to the severe information asymmetry within the insurance market, where customers with the easiest access to high premiums are most likely to actively purchase insurance. Consequently, insurers have a considerable incentive to actively investigate the background of insured companies prior to issuing policies to minimize business risk. Once insured, they will also monitor the potentially risky behavior of senior executives by, for instance, necessitating client companies to appoint a satisfactory number of outside directors. Post-compensation, the opportunistic actions of directors and supervisors can be curbed by elevating insurance premiums and other methods. Core (2000) further emphasizes that insurance companies possess the necessary risk assessment and pricing capabilities to appraise and supervise the risky business decision-making behaviors of listed companies and curtail the improper decisions of directors and supervisors. Contrary to the management incentive hypothesis and external supervision hypothesis, the moral hazard hypothesis suggests that the "duty of diligence" enshrined in D&O insurance is overly abstract and ambiguous. This leads to the coverage of D&O insurance encompassing various civil disputes, except for those instances where directors and officers violate laws and regulations. Consequently, this fosters "over-protection", diminishes directors' self-interested costs, and instigates their potential opportunistic behaviors. For instance, current research indicates that following the procurement of D&O insurance, the opportunistic actions of directors result in improved earnings management, increased financing costs, heightened inefficient mergers and acquisitions, and exacerbated investment and financing term mismatches.

This study's research is also closely aligned with the literature regarding the driving forces of enterprises' digital transformation. Existing studies have underscored the significance of enterprise digital transformation from various perspectives, such as enhancing enterprise performance [14], boosting stock liquidity [5], ameliorating total factor productivity [15], fortifying organizational resilience [16], and facilitating human capital structure adjustments [17]. It is emphasized that digital transformation is a "inescapable choice" for enterprises to adapt to the digital era's development trend and establish competitive advantages. Equally crucial is the question of how to facilitate the digital transformation of enterprises. The existing literature primarily discusses the driving factors of digital transformation at three levels: macro, meso, and micro. Among them, the macro level primarily focuses on government subsidies [6-7], the level of fintech development [18], intellectual property protection [19], and digital infrastructure policies [20]. At the meso level, smart city pilots are highlighted [21], along with industrial synergy and supply chain linkage effects [22-23]. At the micro level, IT mainly explores the influence of corporate organizational characteristics, senior executives' information technology backgrounds [24], and managers' short-sightedness [25]. In summary, numerous studies have highlighted the economic implications of enterprise digital transformation; however, the focus on the motivation behind enterprise transformation, particularly the prerequisites for executive transformation incentives, has been relatively scant.

In instances where ownership and control are separated, directors and supervisors assume control of the enterprise. As the primary executors of enterprise strategy, their perception and attitude towards digital transformation significantly influence its effectiveness. It is anticipated that the operational risk dispersion and decision-making risk loss underwriting effects brought about by the subscription of Directors' and Officers' (D&O) insurance will inevitably have a considerable impact on the risk preferences of directors and senior supervisors, subsequently affecting their perception and attitude towards engaging in high-risk digital transformation behaviors. However, few studies have integrated these two aspects to explore the impact and mechanism of D&O insurance subscription on enterprises' digital transformation. The discussion of this issue in this paper contributes to further unraveling the "black box" of driving factors for enterprises' digital transformation.

2.2. Theoretical analysis

From the perspective of the management incentive hypothesis, the subscription of Directors' and Officers' (D&O) insurance can serve as a hedge against managers' practice risk and mitigate the losses associated with decision-making risk. Additionally, it can alleviate the agency problems resulting from executives' risk aversion and facilitate the digital transformation of enterprises. As previously mentioned, within the framework of principal-agent analysis, corporate executives tend to be risk-averse, maintaining their positions due to concerns regarding salary incentives, career development, and personal reputation, among other factors. In light of the high-risk nature of digital transformation, the attitudes of "reluctance to change" and "fear of change" are prevalent among corporate executives [5-6]. Enhancing the risk tolerance of senior executives is thus essential to promote the digital transformation of enterprises. There are two methods to increase risk tolerance among senior executives: increasing risk return or reducing risk loss. Although D&O insurance cannot augment the executive's transformation risk return, it can effectively transfer the liability costs and property losses resulting from the failure of transformation to the insurance company. This, in turn, creates a transformation incentive and mitigates the principal-agent problem, particularly under the aforementioned attitudes of "reluctance to change" and "fear of change". Furthermore, the subscription of D&O insurance can provide assurance for the sound performance of corporate executives, thereby aiding in the retention and attraction of top-tier management talent. It also offers a stable and proficient senior management team to facilitate enterprises' digital transformation [26] and enhance corporate governance. Notably, risk-averse executives exhibit a greater demand for D&O insurance subscription. This implies that executives who subscribe to D&O insurance tend to have a more pronounced risk aversion tendency and a lower propensity to promote digital transformation. In other words, the impact of D&O insurance subscription on the transformation incentive is significant. In summary, from the perspective of the management incentive hypothesis, D&O insurance can mitigate the losses resulting from executives' failure to promote digital transformation and enhance their capacity to bear the risks associated with digital transformation failure, thereby facilitating enterprises' digital transformation.

Secondly, D&O insurance can contribute to improving the quality of internal control and accelerating the digital transformation of enterprises. First, D&O insurance can enhance the quality of enterprise internal control from two perspectives. On one hand, the external oversight provided by D&O insurance can enhance the quality of enterprise internal control. As an external insurance governance instrument, D&O insurance can facilitate the participation of third-party insurance institutions in the corporate supervision and governance of listed companies [27]. In the face of an increasingly risky business environment, insurance companies, as the bearers of the consequences of directors' actions and significant stakeholders in the company, have a greater incentive to supervise and constrain the business decisions of enterprises. The active supervisory role of D&O insurance can prompt enterprise management to establish a more robust internal control system, minimize loopholes in enterprise internal control, and improve the quality of internal control. On the other hand, D&O insurance safeguards the essential interests of supervisors and also protects the rights and interests of minority shareholders. Since the establishment of the listed company system in China, frequent infringements of minority shareholders' rights and interests have occurred. For small and medium-sized shareholders, they are unable to comprehend the actual business conditions of the company and participate in crucial decision-making processes. This lack of information and resulting disenfranchisement can negatively impact the healthy and orderly development of the entire capital market. The procurement of Directors' and Officers' (D&O) insurance by listed companies can help mitigate information asymmetry within the organization and among various stakeholders. It can also safeguard the rights and interests of minority shareholders, address internal governance shortcomings, and thereby enhance the quality of internal control within the enterprise. Second, improving internal control quality is conducive to promoting the digital transformation of enterprises. Enhancing internal control quality positively influences strategic decision-making and lays the groundwork for digital transformation [29]. Concurrently, as digital transformation and the digital economy advance,

companies are motivated to deeply integrate advanced digital technologies, such as the Internet, big data, artificial intelligence, 5G, and blockchain, into their operations as vital tools to optimize their internal control systems. This, in turn, accelerates the process of digital transformation.

Lastly, D&O insurance enhances enterprise innovation levels and promotes digital transformation. In the current wave of the digital economy, digital transformation has progressively become the core strategic direction of technological change for enterprises, which aids them in gaining the initiative for future development. The 2022 Government Work Report of the State Council unequivocally emphasizes the necessity to "stimulate the growth of the digital economy and fortify the comprehensive blueprint for the construction of a digital China". Governed by this policy directive, digital transformation has emerged as the solitary path for enterprises to achieve superior development. The profound infiltration of enterprise digital transformation expedites the exchange of internal and external knowledge and fosters the innovation and growth of enterprises. The digital transformation of enterprises and corporate innovation are indispensable counterparts. D&O insurance primarily enhances the degree of enterprise innovation from two perspectives. First, from the perspective of the managerial incentive hypothesis, the "sensitivity" of management to the interpretation of external information amplifies crises, underestimates benefits, and hesitates to undertake potential project investment risks. As a risk-transferring tool for enterprise executives, D&O insurance can deflect the litigation risks generated by incorrect innovation decisions or the potential shortcomings of new products, thereby safeguarding them from the losses incurred by innovation failures [30]. Additionally, in instances of managerial decision-making errors, the implementation of D&O insurance can offer corresponding compensations to investors, minimize the wealth erosion of enterprises, and motivate executives to actively perform. Concurrently, D&O insurance has the potential to attract top-notch talents to join the company and inject additional human capital for enterprise innovation. Second, following the acquisition of Dong Ji Insurance by the listed company, the insurance provider will establish relevant provisions to curtail the misconduct of directors and senior supervisors, thereby inhibiting their opportunistic actions, diminishing the agency costs of enterprises, alleviating financing constraints, and offering financial guarantees for the continuous innovation of enterprises, thus enhancing the stability of the implementation of the innovation strategy [31].

3. Index construction, data source and identification strategy

3.1. Index Construction

3.1.1 Dependent variable selection

This study relies on previous research [3-5], employing text analysis and text mining techniques to assess the degree of digital transformation in enterprises based on the proportion of keywords related to "digitalization" in the annual reports of Chinese listed companies, denoted as DIGT.

Enterprise digital transformation is a strategic priority for the current pursuit of high-quality development. This transformation is more likely to be reflected in the annual reports of enterprises, which provide summaries and guidance. The choice of vocabulary in these reports mirrors an enterprise's strategy, showcasing its business philosophy and development path. By analyzing the frequency of digital transformation-related keywords in the annual reports of listed companies, this study quantifies the extent of digital transformation in enterprises. The specific methodology are as follows. First, utilizing the Python crawler function to obtain and organize all annual reports of A-share listed companies on the Shanghai and Shenzhen stock exchanges, followed by extracting all text contents using the Java PDFbox library. Second, extracting high-frequency words related to enterprise digital transformation from the annual reports of listed companies based on the feature words of "application of underlying technology" (such as artificial intelligence, big data, cloud computing, and blockchain) and "application of technology practice" (encompassing digital technology implementation). Subsequently, the Jieba function is employed for word segmentation

processing of all samples, forming a data pool for searching, matching, and counting word spectra according to the collected characteristic word spectra, ultimately generating an aggregate word spectrum. Adding one to the total word spectrum and taking the natural logarithm results in an indicator of the digital transformation of listed companies, represented by DIGT. As the DIGT value increases, the degree of digital transformation of the entity enterprise escalates.

3.1.2 Independent variable selection

In the context of directors' and officers' liability insurance, this study manually examines the archives of listed companies within China Information Bank to ascertain whether these companies possess D&O insurance, the purchasing period, and the insurance liability limit. The disclosed information is cross-checked by CSMAR. The paper's variables are twofold: first, the presence of D&O insurance, which is assigned a value of 1 if the company has introduced the insurance, and 0 otherwise. This variable draws upon existing research [31-32]. Second, the variable DOITIME represents the time of D&O insurance introduction. As the initiation time of DOITIME for each listed company is available, this study calculates the introduction time as the number of years the company introduces DOITIME plus the natural logarithm of 1. This approach allows for the investigation of whether the governance effect of DOITIME alters as the introduction time increases [33].

3.2. Model design

Drawing upon the aforementioned theoretical analysis and extant literature research [35-36], we initially construct a foundational measurement model:

$$DIGT_{it} = \alpha_0 + \alpha_1 DOI_{it} + \alpha_2 Z_{it} + \mu_i + \gamma_j + \delta_t + \varepsilon_{it} \quad (1)$$

In Equation (1), DOI_{it} represents whether enterprise i purchases directors' and officers' liability insurance in period t , and $DIGT_{it}$ signifies the degree of digital transformation undergone by enterprise i in period t . To address the endogeneity issue caused by missing variables, this paper introduces control variables (Z_{it}) and enterprise size (size), measured by the logarithm of total assets, which are drawn from existing literature. Additionally, we consider enterprise age (age), measured by the logarithm of establishment years; business profitability (roa), calculated as net profit divided by total assets; enterprise growth ability (growth), represented by the growth rate of total assets; board size (board), measured by the logarithm of the number of board members; and equity concentration (top3), calculated as the proportion of shares held by the top three shareholders. The proportion of independent directors (indtor), calculated as the ratio of independent directors to the total number of directors; the Fixed assets ratio (fixratio), determined as the ratio of net fixed assets to total assets; and the dual employment arrangement (duality), which is assessed by the concurrent position of the chairman and general manager of a company. To mitigate inter-site heterogeneity and also identify group-level differences, this research incorporates μ_i , which represents the individual fixed effect of the non-temporal change for enterprise i , along with γ_j for the industry fixed effect and δ_t for the time fixed effect. Additionally, this study addresses the systematic heteroscedasticity issue by clustering the random error term $\varepsilon_{i,t}$ at the enterprise level.

3.3. Data sources and descriptive statistics

This study focuses on the A-share listed companies in Shanghai and Shenzhen from 2011 to 2021, excluding financial listed companies, samples with missing financial data or insolvent firms, and those marked with ST or *ST in the current year. A cluster-regression analysis at the firm level was conducted to mitigate the effects of heteroscedasticity and control for differences between data groups. The financial data employed in this research were obtained from the CSMAR database. A summary of the descriptive statistics for relevant variables is presented in Table 1.

Table1. Descriptive statistics²

Variable	Obs	Mean	Std. Dev.	Min	Max
<i>DIGT</i>	40031	1.356	0.647	0.000	4.585
<i>DOI</i>	40031	0.082	0.275	0.000	1.000
<i>size</i>	36491	22.117	1.426	15.573	30.998
<i>age</i>	40154	2.764	0.416	0.000	4.143
<i>roa</i>	33037	0.047	0.165	-1.683	20.788
<i>growth</i>	30051	0.580	29.095	-0.972	4719.612
<i>board</i>	35603	2.126	0.204	0.000	3.045
<i>top3</i>	32619	34.528	15.073	0.286	89.991
<i>indtor</i>	32591	0.376	0.056	0.143	1.000
<i>fixratio</i>	33014	0.205	0.161	0.000	0.985
<i>duality</i>	35930	0.317	0.554	0.000	33.515
<i>cash</i>	32122	0.212	0.156	0.000	1.000
<i>loss</i>	32122	0.099	0.298	0.000	1.000

4. Empirical analysis

4.1. Baseline regression

Significant positive correlations at the 1% level are observed between enterprise digital transformation and the introduction of D&O insurance in both the OLS model and the fixed-effects model, when only year and industry dummy variables are controlled. This indicates a significant positive relationship between digital transformation and D&O insurance. Furthermore, the regression results reveal the impact of a range of control variables on DIGT. In columns (2) and (4), the coefficients for company size and board size exhibit significantly opposing trends. Specifically, larger companies tend to have higher DIGT values, while companies with larger boards tend to have lower DIGT values. The fixed assets ratio coefficient exhibits a similar effect. The coefficient for company age demonstrates a significantly positive trend in column (2) but a significantly negative trend in column (4), suggesting that the impact of company age on DIGT may vary depending on the model configuration. The coefficient for firm growth ability has no discernible effect on DIGT. Moreover, in all models, the effect of the top three shareholders' shareholding ratio coefficient on DIGT is virtually nil. A significant positive correlation is observed between the size coefficient of independent directors and the two-in-one ratio coefficient in columns (2) and (4).

Based on the regression analysis, it is evident that D&O insurance has a considerable positive influence on DIGT. A company's subscription to increased D&O insurance coverage is directly correlated with an increase in its DIGT value. This could be attributed to the fact that D&O insurance mitigates the personal risks executives face due to inadequate performance of their duties. Consequently, this reduces the executives' stress levels, enhances their work efficiency, and improves the quality of their decisions. These factors, in turn, contribute positively to the company's performance. Moreover, other control variables such as the company's size, the shareholding ratio of the top three shareholders, and the proportion of fixed assets also have varying degrees of impact on DIGT.

In terms of model fitness, the adjusted R-square values for the fixed effect model are notably high (0.517 and 0.544, respectively), indicating that the model provides an adequate explanation for the variations in DIGT. Particularly, in column (4), the model's fitness further improves after the inclusion of a series of control variables. This suggests that the impact of variable factors on DIGT cannot be overlooked and should be taken into account in empirical analyses.

Table3. Baseline regression

	OLS		Fixed effects	
	(1)	(2)	(3)	(4)
<i>DIGT</i>	0.438*** (0.014)	0.328*** (0.014)	0.100*** (0.012)	0.094*** (0.012)
<i>size</i>		0.061*** (0.003)		0.025*** (0.002)
<i>age</i>		0.380*** (0.009)		-0.063*** (0.008)
<i>roa</i>		-0.043*** (0.014)		0.023** (0.010)
<i>growth</i>		-0.000*** (0.000)		-0.000*** (0.000)
<i>board</i>		-0.437*** (0.022)		-0.034** (0.016)
<i>top3</i>		-0.001*** (0.000)		0.001*** (0.000)
<i>indtor</i>		-0.021 (0.076)		0.130** (0.054)
<i>fixratio</i>		-0.879*** (0.022)		-0.445*** (0.022)
<i>duality</i>		0.114*** (0.008)		0.016*** (0.006)
<i>_cons</i>	1.334*** (0.003)	0.013 (0.077)	1.351*** (0.002)	1.028*** (0.063)
<i>Year FE</i>	N	N	Y	Y
<i>Industry FE</i>	N	N	Y	Y
<i>N</i>	40031	29837	40025	29837
<i>adj. R²</i>	0.021	0.157	0.517	0.544

Note: ***, ** and * indicate significant at 1%, 5% and 10% levels respectively, with robust standard error in brackets (same as in the table below)

4.2. Robust analysis

Considering the influence of disparate measurement methods of the indicators on the research findings, this study conducts a robustness test by substituting the core explanatory variables and the explained variables. Initially, the benchmark regression employs Wu Fei et al. (2021) to assess the extent of enterprise digital transformation, while the robustness test utilizes the method devised by Yuan Chun et al. (2021). The results presented in Column (1) of Table 3 indicate that the outcomes following the substitution of variables are predominantly consistent with the results of the benchmark regression, thereby verifying the reliability of the central conclusion.

Industries with an advanced technological status or cities with a high level of economic development may possess relatively comprehensive digital infrastructure, thereby providing enterprises with greater advantages in the advancement of digital transformation. Consequently, this study incorporates an interactive fixed effect between industry and year to control the influence of factors that vary year by year at the industry and city levels, and thereby alleviate the fluctuations in the macro environment induced by the progression of the digital economy [1]. The regression results displayed in Column (2) of Table 3 demonstrate a significantly positive estimated coefficient for enterprise digital transformation, which is essentially consistent with the benchmark regression findings.

To mitigate the estimation error induced by missing variables, additional variables are incorporated in this study: Cash = (monetary funds + transactional financial assets)/total assets, loss

= net profit of the year is 1 if it's negative, and 0 otherwise. The outcomes are delineated in column (3) of Table 3. The coefficients of the primary explanatory variables remain notably positive, in line with the baseline findings.

The standard regression model elucidates the influence of DCI in the mean range on the digital transformation of enterprises, but disregards the impact of DCI on the digital transformation of the entire conditional distribution enterprises, which may result in challenges in accurately estimating the effect of DCI on the digital transformation of enterprises [8]. In this research, panel quantile regression model is opted to scrutinize the effects of heterogeneity at diverse loci, completely reflecting the distribution of explanatory variables without being influenced by extreme values. Columns (4) to (6) in Table 3 present the varying regression results of digital transformation on OFDI at different quantiles. It's discerned that there's a significant disparity in the influence of digital transformation on OFDI at various loci, and the coefficient estimation value of digital transformation exhibits a downward tendency as the quantile increases.

Table4. Robustness test

	(1) DIGT2	(2) DIGT	(3) DIGT	(4) Q=0.25	(5) Q=0.5	(6) Q=0.75	(7) IV_MEAN	(8)
<i>DOLA</i>	0.055** (0.028)	0.328*** (0.014)	0.093*** (0.012)	0.693*** (0.000)	0.392*** (0.044)	0.302*** (0.064)		0.124*** (0.034)
IV_MEAN							0.837*** (0.028)	
<i>size</i>	0.155*** (0.005)	0.061*** (0.003)	0.027*** (0.002)	0.000 (0.000)	0.158*** (0.008)	0.108*** (0.011)	0.015*** (0.002)	0.107*** (0.005)
<i>age</i>	-0.100*** (0.019)	0.380*** (0.009)	-0.061*** (0.008)	0.000 (0.000)	0.249*** (0.031)	0.129*** (0.036)	0.079*** (0.009)	1.685*** (0.022)
<i>roa</i>	0.001 (0.019)	-0.043*** (0.014)	0.026*** (0.009)	-0.000 (0.000)	-0.054 (0.093)	-0.133 (0.112)	0.003 (0.003)	-0.010 (0.018)
<i>growth</i>	-0.000 (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000 (0.000)	0.000 (0.001)	-0.000 (0.001)	0.000 (0.000)	-0.000 (0.000)
<i>board</i>	0.092** (0.036)	-0.437*** (0.022)	-0.036** (0.016)	-0.000 (0.000)	-0.399*** (0.055)	-0.420*** (0.078)	0.417*** (0.015)	-0.096*** (0.020)
<i>top3</i>	-0.003*** (0.000)	-0.001*** (0.000)	0.001*** (0.000)	-0.000 (0.000)	-0.008*** (0.001)	-0.012*** (0.001)	0.000 (0.000)	-0.001** (0.000)
<i>indtor</i>	0.469*** (0.129)	-0.021 (0.076)	0.124** (0.054)	0.000 (0.000)	1.011*** (0.217)	1.086*** (0.288)	0.039 (0.045)	0.004 (0.061)
<i>fixratio</i>	-1.286*** (0.045)	-0.879*** (0.022)	-0.418*** (0.023)	-0.000 (0.000)	-2.488*** (0.060)	-3.543*** (0.080)	-0.056*** (0.016)	-0.192*** (0.029)
<i>duality</i>	0.031** (0.013)	0.114*** (0.008)	0.016*** (0.006)	0.000 (0.000)	0.212*** (0.026)	0.200*** (0.027)	0.002 (0.003)	0.002 (0.005)
<i>cash</i>			0.095*** (0.020)					
<i>loss</i>			0.020** (0.009)					
<i>_cons</i>	-1.815*** (0.145)	0.013 (0.077)	0.959*** (0.064)	-0.000 (0.000)	-1.901*** (0.214)	1.087*** (0.303)		
Kp rk LM								779.279***
Kp rk Wald F								883.269
Stock-Yogo 10%								16.38
<i>Year FE</i>	Y	Y	Y	Y	Y	Y	Y	Y
<i>Industry FE</i>	Y	Y	Y	Y	Y	Y	Y	Y
<i>Year*Industry FE</i>		Y						
<i>N</i>	29689	29837	29837	29689	29689	29689	29266	29266
<i>adj. R²</i>	0.483	0.157	0.544	0.482	0.482	0.482	0.642	0.642

4.3. Endogeneity test

Enterprises in the same industry share significant similarities in terms of business risk, market environment, and economic cycle. Owing to direct competition in the talent market, companies often refer to their competitors' choices when purchasing Directors' and Officers' (D&O) insurance. However, there is no direct evidence to suggest that the proportion of D&O insurance purchased within the same industry influences enterprises' digital transformation. To address this issue, this study draws upon existing research [34-35] and employs the mean value of D&O insurance purchased by listed companies in the same year and industry (IV_MEAN) as the instrumental variable for DOI.

In Table 3, columns (7) and (8) present the estimation results obtained using the instrumental variables method, which employs a two-stage least square estimation technique. The first stage of the model, as reflected in column (7), demonstrates a significant correlation between the instrumental variables and D&O insurance variables. The second stage estimation results in column (8) reveal a significantly positive correlation between the enterprise digital transformation variable and the D&O insurance variable at the 1% level, which is consistent with the benchmark regression estimation outcomes. Both the under-identification test and weak identification test reject the null hypothesis, thereby validating the rationale behind the choice of instrumental variables. Consequently, the conclusion that D&O insurance fosters enterprises' digital transformation is relatively robust.

5. Conclusion and Enlightenment

5.1. Research Conclusion

This study examines the impact and mechanism of Directors' and Officers' (D&O) accountability insurance on the digital transformation of enterprises, using Shanghai-Shenzhen A-share listed companies from 2011 to 2021 as sample cases. The key findings are as follows:

First, the subscription of D&O insurance can facilitate the digital transformation of enterprises, with a significantly positive impact on the transformation process. This promotional effect remains consistent even after undergoing a series of robustness tests.

In addition, the mechanism test reveals that D&O insurance significantly raises the level of risk-bearing among enterprise managers, enhancing management efficiency and thereby promoting the development of digital transformation. By increasing the risk tolerance of executives, improving the quality of internal control, and boosting the innovation capacity of enterprises, D&O insurance exerts both incentive and supervisory effects, driving the digital transformation process.

Lastly, further analysis indicates that executive equity incentives and executive insurance play complementary roles in promoting enterprises' digital transformation.

The research outcomes of this study demonstrate that the subscription of D&O insurance has become a crucial factor in enhancing the effectiveness of enterprises' digital transformation and promoting high-quality economic development.

5.2. Countermeasures and Suggestions

In the context of the rapidly evolving digital economy of Chinese enterprises, D&O insurance serves as an effective external incentive and supervisory mechanism, capable of exerting internal and external governance effects in corporate governance, and significantly advancing the digital transformation of enterprises. Based on this, the following suggestions are proposed:

First and foremost, encourage enterprises to procure D&O insurance as a facilitator for the implementation of their digital transformation strategies. This study finds that D&O insurance can facilitate enterprises' digital transformation by adjusting executives' risk tolerance and enhancing enterprises' risk-bearing capacity. For enterprises, D&O insurance represents an essential risk management instrument, possessing significant importance for improving corporate governance and augmenting the efficiency of principal-agent relationships. However, it is observed that only approximately 7% of listed companies in China have subscribed to D&O insurance, a significant

discrepancy compared to developed capitalist countries in Europe and the United States. This indicates that Chinese enterprises have an inadequate understanding of the crucial role played by D&O insurance, which impedes the smooth progression of their digital transformation strategies. Consequently, enterprises should be encouraged to purchase D&O insurance, mitigating and resolving risk points during operational processes, and aiding the execution of their digital transformation strategies. Moreover, in China's imperfect corporate governance system, the degree of information asymmetry among enterprises is pronounced, with the role of information media being paramount. The procurement of D&O insurance not only mitigates the impact of external risks, transfers litigation risks, improves managers' risk tolerance, but also monitors the performance of directors' and senior supervisors, fortifies internal controls, and enhances information transparency.

Furthermore, enhance the corporate governance framework and expedite the digital transformation of enterprises sound corporate governance is a prerequisite for the long-term healthy development of listed companies and the elevation of the capital market. To prevent major shareholders and professional managers from colluding to harm the interests of minority shareholders, curtail directors' abuse of power engaging in financial fraud, illicit transactions, and insufficient information disclosure, companies can optimize the functions of shareholders' meetings and augment the quality of information disclosure from listed companies to restrain their behavioral decisions. The beneficial impact of D&O insurance on enterprises' digital transformation should not be regarded as "one-size-fits-all." This study reveals that the promotional effect of D&O insurance is particularly pronounced for non-high-tech enterprises, regions with robust legal environments, and enterprises with significant income incentives for digital transformation. This indicates that varying types of enterprises have distinct practical foundations and transformation challenges, resulting in substantial discrepancies in the effectiveness of D&O insurance for enterprises' digital transformation. For non-high-tech enterprises and those in regions with robust legal environments, such enterprises should be encouraged to proactively purchase D&O insurance, fortify risk management, and stimulate executives to facilitate digital transformation. Attending to the upgrading of human capital induced by digital transformation can yield the effects of technology dissemination, which is advantageous to the betterment of the total factor productivity of enterprises and the amelioration of the development quality of enterprises.

Ultimately, enhance corporate governance and fortify talent development. The advent of modern corporate enterprises has fostered the division of labor in society, yet it has also given rise to the principal-agent problem. Due to concerns regarding reputation and career, executives tend to be risk-averse and exhibit a negative attitude towards strategic, long-term, and complex transformations such as digital transformation. Effective corporate governance can effectively curb the opportunistic behavior of management, facilitate the alignment of executive interests with those of the company, mitigate short-sightedness, and facilitate digital transformation. Simultaneously, the risk-averse attitude of top executives represents a significant barrier to the advancement of digital transformation strategies. Overcoming the risk-averse tendency of senior executives through talent development and incentive mechanisms is crucial for the execution of digital transformation strategies. By implementing digital transformation strategies, constructing digital infrastructure, adopting data-driven decision-making, and strengthening digital talent development, companies can accomplish digital transformation, enhance efficiency, optimize operations, and bolster competitive advantages.

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