



Unexpected discrimination: Does directors' and officers' liability insurance exacerbate credit mismatch?

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ABSTRACT

Credit mismatch constrains firm growth and financial stability, particularly in emerging markets. While directors' and officers' liability insurance (D&O insurance) strengthens governance, its credit allocation remains unexplored. We pioneer in showing D&O insurance exacerbates credit mismatch in China by increasing interest costs for firms with above-average initial expenses, driven by credit provider' risk discrimination instead of managerial opportunism. Heterogeneity analysis indicates that non-state-owned firms, firms with smaller supervisory boards, and firms with lower institutional shareholding experience stronger adverse effects, suggesting that weaker institutional credibility amplifies credit discrimination. However, digital technology adoption and corporate information disclosure help mediate this effect, reducing credit mismatch.

1. Introduction

Credit markets are imperfect and volatile, often experiencing simultaneous excess demand and supply of credit, leaving firms struggling to obtain financing despite available capital (Becsi et al., 2013). Credit mismatch distorts capital allocation, resulting in higher borrowing costs due to the misalignment between financing terms and firms' development needs (Zhang et al., 2023). In emerging markets, this mismatch constrains investment efficiency and economic growth (Zhang et al., 2024), making it crucial to understand its underlying determinants.

Directors' and officers' liability insurance (D&O insurance) protects corporate executives from claims arising from their managerial decisions and has been widely adopted as a governance-enhancing tool globally (Jia et al., 2019). While D&O insurance can enhance governance, its impact on credit mismatch remains unclear. In theory, D&O insurance may alleviate credit mismatch by enhancing corporate disclosure and improving managerial incentives. It introduces insurance firms as external monitors, requiring firms to undergo rigorous governance assessments before underwriting and continuous oversight (O' Sullivan, 1997; Yuan et al., 2016). To comply with insurers' scrutiny and oversight, insured firms tend to improve disclosure quality, reducing information asymmetry. Additionally, D&O insurance provides legal protection, allowing executives to pursue profitable but higher-risk projects, enhancing risk-taking efficiency and aligning decisions with shareholder interests. However, the opportunism perspective argues that while D&O insurance is intended to alleviate litigation risk (Lin et al., 2011), it may undermine shareholder litigation as a governance mechanism, potentially leading to moral hazard (Lin et al., 2022). As insurance covers legal costs and potential damages, directors and officers

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(D&Os) may engage in opportunistic behavior.

The relationship between D&O insurance and credit mismatch may be more complex in emerging markets, where credit providers play a crucial role in financing decisions. In developed markets, well-established legal systems and fair competition reduce reliance on political ties for shielding firms from litigation risk (Lu et al., 2015). However, in emerging economies, where formal governance mechanisms are often underdeveloped, financial institutions tend to rely on informal governance tools, such as political connections (Dinh and Hilmarsson, 2020). Due to the reliance on informal governance, credit providers in emerging markets may perceive D&O insurance as a risk signal rather than a safeguard, as weaker governance structures can heighten concerns about managerial opportunism and risk-taking behaviors.

In recent years, tightened loan conditions have increased financing barriers, exacerbating credit access challenges in China (Luo and Li, 2025). The 2024 amendment to China's Company Law formalized the status of D&O insurance, requiring boards to disclose relevant insurance details to shareholders, reinforcing its governance role. Thus, it is crucial to examine whether D&O insurance exacerbates credit discrimination, offering insights into its broader implications for corporate financing and financial stability in emerging markets.

Using the data from Chinese listed firms between 2003 and 2022, this study examines the impact of D&O insurance on credit mismatch. Our findings reveal that D&O insurance exacerbates credit mismatch by increasing credit interest expenses for firms already facing above-average borrowing costs. Furthermore, this mismatch arises not from managerial opportunism but from credit providers' discriminatory perception. Contrary to concerns about moral hazard, our empirical tests find no significant relationship between D&O insurance and managerial opportunistic behavior, reinforcing that credit mismatch in China arises from discrimination rather than increased risk-taking. Additionally, heterogeneity analysis shows that non-state-owned firms, firms with smaller supervisory boards, and firms with lower institutional shareholding experience stronger adverse impact. To address this issue, we explore potential mitigation mechanisms and find that digital technology adoption and corporate information disclosure help reduce credit mismatch.

This study makes several contributions. First, it is the first to examine the relationship between D&O insurance and credit mismatch, offering new insights into its role in corporate financing. While developed markets regard D&O insurance as a governance-enhancing tool, credit providers in emerging markets often interpret it as a risk signal, increasing credit expenses for firms already facing high credit expenses. Second, it highlights the role of discrimination in credit allocation. Our findings challenge the moral hazard hypothesis, showing that credit mismatch stems from market skepticism rather than managerial risk-taking. Third, this study emphasizes the need for enhanced financial transparency and digital technology adoption to reduce credit discrimination.

Table 1

Variable definitions and descriptions.

Variable	Definitions and Operations
Dependent variable	
CM	Ratio of the absolute value of the difference between a firm's cost of capital and the industry average cost of capital to the industry average cost of capital (Luo and Li, 2025; Qin and Gong, 2024).
Independent variable	
Insured	Takes a value of 1 if the firm purchases D&O insurance, and 0 otherwise.
Moderator variable	
DIF	Digital Inclusive Finance Index from the Peking University Digital Finance Research Center. Considering the coefficient visibility, the original value is reduced 10 times.
FT	Takes a value of 1 if the firm is located in the FinTech pilot city, and 0 otherwise.
Transparency	Annual rating of accounting disclosure quality by the Shenzhen and Shanghai Stock Exchanges.
Disclosure	Absolute value of corporate disclosure management based on the modified Jones model accounting.
Control variable	
Size	Natural logarithm of total assets.
Lev	Total liabilities divided by total assets.
ROA	Net profit divided by total assets.
Cashflow	Net cash flow divided by total assets.
Growth	Growth rate of operating income.
Board	Natural logarithm of the number of board members plus one.
Dual	Takes a value of 1 if the CEO is also the Chairman, and 0 otherwise.
FirmAge	Natural logarithm of the firm's age plus one.
Top5	Shareholding percentage of the top 5 shareholders.
Q	Tobin's Q.
Indep	Percentage of independent directors on the board.
INST	Institutional shareholding percentage.
Mshare	Management shareholding percentage.
SA	Financing constraints measured by the SA index.
Bank	Takes a value of 1 if the enterprise holds shares in the bank, and 0 otherwise.
Otherfin	Takes a value of 1 if the enterprise holds shares in other financial institutions, and 0 otherwise.

2. Research design

2.1. Data

To explore the impact of D&O insurance on credit mismatch, this study uses data from Chinese A-share listed companies between 2003 and 2022. The following categories of firms are excluded from the sample: (i) firms in the financial sector; (ii) firms with significant missing data; (iii) ST and *ST firms. To mitigate the influence of outliers, continuous variables are winsorized at the upper and lower 1 % percentiles. The data of D&O insurance is obtained from the Chinese Research Data Services Platform (CNRDS), and all other firm-related data are obtained from the China Stock Market and Accounting Research (CSMAR) database.

2.2. Variable definition

The definition and description of variables used in this study are shown in Table 1.

2.3. Model design

We construct the following model to examine the impact of D&O insurance on credit mismatch:

$$CM_{i,t} = \beta_0 + \beta_1 Insured_{i,t} + \beta_2 Control_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

Where subscript i and t represent firms and years, respectively, $CM_{i,t}$ denotes the difference between the actual credit interest expense and the industry average level, $Insured_{i,t}$ is a dummy variable indicating whether the firm has purchased D&O insurance, and $Control_{i,t}$ represents a set of control variables listed in Table 1. δ_i and γ_t denote firm fixed effects and year fixed effects, respectively, while $\varepsilon_{i,t}$ represents the error term.

2.4. Descriptive statistics

Table 2 presents the descriptive statistics of the variables used in this study. The data does not exhibit any anomalies or outliers.

3. Empirical results

3.1. Benchmark results

To examine the relationship between D&O insurance and credit mismatch, we use credit mismatch as the dependent variable in

Table 2
Descriptive statistics.

Variables	(1) Obs.	(2) Mean	(3) S.D.	(4) Min	(5) Max
CM	36,724	0.681	0.555	0.011	3.704
Insured	36,724	0.123	0.329	0	1
Size	36,724	22.170	1.275	19.692	26.094
Lev	36,724	0.454	0.200	0.056	0.904
ROA	36,724	0.031	0.066	−0.277	0.194
Cashflow	36,724	0.048	0.072	−0.178	0.251
Growth	36,724	0.369	1.041	−0.790	7.268
Board	36,724	2.261	0.184	1.099	2.996
Dual	36,724	0.239	0.426	0	1
FirmAge	36,724	2.284	0.626	0.693	3.497
Top5	36,724	0.519	0.152	0.192	0.893
Q	36,724	2.507	1.811	0.876	11.732
Indep	36,724	0.370	0.054	0.200	0.571
INST	36,724	0.462	0.236	0.002	0.916
Mshare	36,724	0.094	0.167	0	0.675
SA	36,724	−3.777	0.270	−4.397	−2.872
Bank	36,724	0.079	0.270	0	1
Otherfin	36,724	0.065	0.247	0	1
Rep_CM1	36,724	0.014	0.011	0.001	0.071
Rep_CM2	36,724	0.016	0.843	−1	2.938
Disclosure	36,337	0.070	0.074	0.001	0.414
Risk	36,724	0.039	0.076	0	0.453
SelfTimes	33,794	0.338	0.703	0	4.466
DIF	25,725	24.211	7.725	5.916	35.153
FT	36,724	0.232	0.422	0	1
Transparency	36,724	2.450	1.055	1	4

Column (1) of Table 3 and introduce control variables in Column (2). To ensure robustness, we first define credit mismatch as the absolute difference between a firm's cost of capital and the industry average cost of capital. The results in Column (5) confirm a positive association between D&O insurance and credit mismatch, suggesting that D&O insurance exacerbates credit mismatch. Then, following Wang et al. (2024), we construct an alternative measure using the ratio of the difference between a firm's cost of capital and the industry average cost of capital to the industry average cost of capital, without taking the absolute value. The results in Column (6) remain consistent with our main findings, reinforcing the robustness of our conclusions.

To better understand the cause of this credit mismatch, we follow Qin and Gong (2024) and analyze its direction. Specifically, we differentiate between right mismatch (i.e., firms with initial credit costs above the industry average) and left mismatch (i.e., firms with initial credit costs below the industry average) in Column (3) and (4), respectively. The results show that D&O insurance significantly exacerbates right mismatch but has no statistically significant effect on left mismatch. This indicates that D&O insurance increases credit interest expenses for firms whose initial expenses already exceed the industry average but does not reduce costs for those with below-average credit interest expenses.

Although D&O insurance is designed to mitigate litigation risk (Lin et al., 2011), it may also encourage managerial risk-taking behavior (Boyer and Tennyson, 2015). Consequently, credit providers may interpret its purchase as a defensive strategy shielding executives from governance and legal consequences rather than a governance-enhancing tool. Specifically, they associate D&O-insured firms with greater exposure to potential lawsuits, regulatory scrutiny, or financial instability. Compared to developed markets, financial institutions in emerging markets tend to distrust formal governance tools and instead favor informal governance tools like political ties (Dinh and Hilmarsen, 2020). This skepticism leads credit providers to impose stricter lending conditions on insured firms, thereby exacerbating credit mismatch.

3.2. Robustness test

3.2.1. System GMM

In the baseline results, we find that D&O insurance exacerbates credit mismatch. However, there are inherent endogeneity issues due to omitted variables. To mitigate this concern, we employ the system GMM approach, and the results are presented in Table 4. The results indicate that D&O insurance remains positively and significantly associated with credit mismatch across all specifications. These findings corroborate our baseline results and confirm that D&O insurance significantly exacerbates credit mismatch.

3.2.2. Propensity score matching

Considering the potential systematic differences between firms that purchase D&O insurance and those that do not, we employ the PSM method to mitigate endogeneity concerns arising from sample selection bias. The results of nearest-neighbor matching and radius matching, presented in Table 5, show that the coefficients on D&O insurance remain significantly positive, confirming that D&O insurance exacerbates credit mismatch. The balance test results, presented in Tables A1 and A2 and Figs. A1 and A2, demonstrate that the PSM method effectively reduces selection bias and improves the comparability between treated and control firms, ensuring the robustness of our findings.

3.2.3. Adjustment for fixed effects and clustering levels

To mitigate potential bias from unobservable confounding factors, we adjust for fixed effects and clustering criteria. The results, illustrated in Fig. 1, show that D&O insurance still exacerbate credit mismatch, confirming that our results are robust.

4. Further analysis

4.1. The impact on managerial opportunistic behavior

From the baseline results, we find that the purchase of D&O insurance leads to an increase in credit mismatch, which we attribute to credit providers' discrimination. However, existing research associates D&O insurance with increased moral hazard and a higher

Table 3
Benchmark results.

Variables	$CM_{i,t}$				$Rep_CM_{i,t}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Insured	0.0329** (0.0155)	0.0462*** (0.0151)	0.0827*** (0.0272)	0.0023 (0.0119)	0.0006** (0.0003)	0.0359* (0.0203)
Control	NO	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	36,724	36,724	17,520	19,204	36,724	36,724
R-squared	0.276	0.290	0.323	0.471	0.261	0.463

Notes: Standard errors clustered to the firm level are in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The clustering levels and significance symbols in this study remain unchanged and are not annotated below. The coefficients of other variables are not reported to save space.

Table 4
Results of system GMM.

Variables	$CM_{i,t}$			
	One-step		Two-step	
	Normal (1)	Orthogonal (2)	Normal (3)	Orthogonal (4)
Insured	0.2168*** (0.0820)	0.1944*** (0.0748)	0.1890*** (0.0708)	0.1811*** (0.0683)
Control	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	30,628	30,628	30,628	30,628
AR (1)	0.000	0.000	0.003	0.004
AR (2)	0.650	0.885	0.203	0.404
Hansen test	0.755	0.305	0.853	0.680

Notes: The results of AR (1) indicate the presence of first order autocorrelation and the results of AR (2) indicate the absence of second order serial autocorrelation. The results of Hansen test also indicate no over-identification of the instrumental variables used, confirming the reliability of the model fit.

Table 5
Results of propensity score matching.

Variables	$CM_{i,t}$	
	Neighbor Matching (1)	Radius Matching (2)
Insured	0.0330** (0.0159)	0.0454*** (0.0151)
Control	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Observations	21,587	36,562
R-squared	0.339	0.291

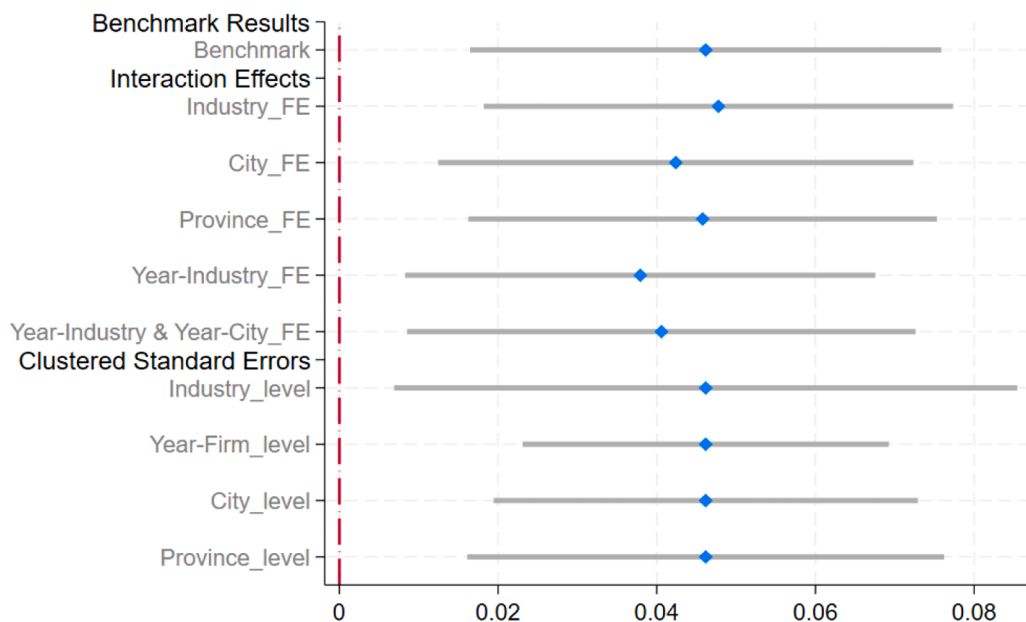


Fig. 1. Fixed effects and clustering adjustment.

Notes: The gray line in the figure represents the 95 % confidence interval, and the red dashed line represents the baseline 0 value. This study adds industry, city, province, year-industry interaction, and year-industry and province interaction fixed effects to the baseline model, respectively. Meanwhile, this study also examines the clustering criteria by adjusting the original clustering standard to industry, industry, year-firm interaction, year-city interaction, and year-province interaction clustering criteria error.

likelihood of opportunistic behavior by directors and officers (Boyer and Tennyson, 2015; Lin et al., 2022). If credit providers raise credit interest expenses based on concerns over managerial opportunism, this would be a rational risk-pricing decision rather than discrimination. To distinguish between these two explanations, we further examine the relationship between D&O insurance and managerial opportunistic behavior.

Following prior studies, we measure managerial opportunism using earnings management (Jones, 1991; Kim et al., 2024), risk propensity (Walls and Dyer, 1996; Chen et al., 2022), and insider trading behavior (Cai et al., 2022). The results in Table 6 show no significant association between D&O insurance and managerial opportunism, indicating that D&O insurance does not encourage managerial opportunistic behavior. Moreover, despite these effects are not statistically significant, the coefficients suggest a potential reduction in risk propensity and the transaction behavior of insider trading in stock, further reinforcing that D&O insurance does not increase managerial opportunism in China.

The absence of managerial opportunism in this case may be due to stronger political influence, which imposes strong external constraints on corporate governance in emerging markets (Jia et al., 2019), reducing the likelihood of opportunistic behavior. Thus, the observed increase in credit mismatch is not driven by firms engaging in managerial opportunistic behavior but rather by credit providers' discriminatory perception of D&O insurance.

4.2. Heterogeneity analysis

In the previous analysis, we found that D&O insurance exacerbates credit mismatch due to discrimination. If this interpretation holds, firms that face less institutional discrimination, such as those with strong political connections and effective governance oversight, should experience a weaker impact on credit mismatch. As shown in Table 7, Columns (1) and (2), D&O insurance significantly increases credit mismatch only in non-state-owned firms, while its effect is insignificant for state-owned firms. This may be because political connections shield firms from financial discrimination by providing legal advantages and preferential access to financial resources, including bank loans (Berkman et al., 2010; Lin et al., 2020; Jia et al., 2019), reducing credit providers' reliance on D&O insurance as a risk signal and mitigating its impact on credit mismatch.

The results in Columns (3) and (4) indicate that D&O insurance exacerbates credit mismatch only in firms with smaller supervisory boards, whereas the effect is insignificant in firms with larger supervisory boards. This finding suggests that strong internal governance can counteract negative perception of D&O insurance. Supervisory boards help monitor managerial actions and mitigate agency conflicts (Lu et al., 2022). When supervisory board oversight is strong, management misconduct risks decrease, making firms less likely to use D&O insurance as a defensive strategy. Consequently, credit providers are less skeptical of D&O-insured firms with stronger supervisory board oversight, reducing the impact of D&O insurance on credit mismatch.

As shown in Columns (5) and (6), D&O insurance significantly increases credit mismatch only in firms with lower institutional shareholding. Institutional shareholders enhance financial transparency and improve external monitoring, which increases credit providers' confidence in their governance quality (Jiang et al., 2021). As a result, D&O insurance has a weaker effect on credit mismatch in these firms because institutional shareholders act as a counterbalance to any adverse impact or risk perception associated with D&O insurance.

4.3. The improvement of credit mismatches

Credit mismatch is largely attributed to credit providers' discrimination, which stems from information asymmetry between lenders and firms. To address this issue, we employ a moderation effect model, incorporating both external and internal approaches to mitigate information asymmetry. The regression model is specified as follows:

$$CM_{i,t} = \beta_0 + \beta_1 Insured_{i,t} \times N_{i,t} + \beta_2 Insured_{i,t} + \beta_3 N_{i,t} + \beta_4 Control_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (2)$$

Table 6
Results of the impact on managerial opportunistic behavior.

Variables	Earnings Management <i>Disclosure_{i,t}</i> (1)	Risk Propensity <i>Risk_{i,t}</i> (2)	Insiders' Trading <i>SellTimes_{i,t}</i> (3)
Insured	0.0015 (0.0018)	−0.0027 (0.0020)	−0.0168 (0.0179)
Control	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	36,337	36,724	33,794
R-squared	0.178	0.537	0.318

Notes: The variable construction methodology in this study follows established approaches used in the cited literature. Specifically, earnings management (*Disclosure_{i,t}*) is measured using discretionary accruals based from the modified Jones model (Jones, 1991; Kim et al., 2024). Risk propensity (*Risk_{i,t}*) is assessed by the ratio of risky assets to total assets (Walls and Dyer, 1996; Chen et al., 2022). Insider' trading (*SellTimes_{i,t}*) is identified as an opportunistic reduction when a single reduction transaction by directors, supervisors, and executives predicts negative stock reporting in the coming month, and the amount is counted (Cai et al., 2022). Due to space constraints, detailed measurement specifications are not reported here. Readers seeking further methodological details may refer to the cited studies.

Table 7
Results of heterogeneity analysis.

Variables	$CM_{i,t}$					
	Ownership Structure		Supervisory Board		Institutional Shareholding	
	State (1)	Non-state (2)	Big (3)	Small (4)	High (5)	Low (6)
Insured	0.0204 (0.0212)	0.0569*** (0.0208)	0.0313 (0.0209)	0.0675*** (0.0220)	0.0324 (0.0199)	0.0621*** (0.0230)
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	15,872	20,208	21,163	15,561	18,361	18,363
R-squared	0.305	0.293	0.274	0.305	0.293	0.282
Bdiff	p-value = 0.000***		p-value = 0.020**		p-value = 0.010**	

Notes: This study classifies the full sample into the following subsamples: (i) state-owned and non-state-owned firms based on the ownership type of the firms, (ii) firms with larger versus smaller supervisory boards based on the median size of corporate supervisory boards, and (iii) firms with higher versus lower institutional shareholding, based on the median level of institutional shareholding. *Bdiff* is the code used in STATA for between-group coefficient tests where a significant result indicates a significant difference between two groups.

Where $N_{i,t}$ denotes moderating variables include digital technology adoption and corporate information disclosure. All other model specifications are consistent with Eq. (1).

4.3.1. Digital technology

Digital technology improves investment efficiency, optimizes capital allocation, and reduces corporate financing costs. Table 8, Columns (1) and (2) show that the interaction terms between D&O insurance and digital inclusive finance, as well as D&O insurance and the fintech pilot policy, are significantly negative, suggesting that digital technology mitigates the adverse impact of D&O insurance on credit mismatch. By improving credit providers' availability to assess firm risk and performance, digital technology reduces information asymmetry, enhance credit risk assessment, and facilitates more effective capital allocation, thereby offsetting the adverse impact of D&O insurance on credit mismatch (Lan et al., 2024).

4.3.2. Corporate information disclosure

Corporate information disclosure is crucial in reducing information asymmetry between firms and investors. While D&O insurance

Table 8
Results of moderation effect.

Variables	$CM_{i,t}$			
	(1)	(2)	(3)	(4)
Insured	0.1948*** (0.0703)	0.0646*** (0.0169)	0.1438*** (0.0373)	0.0256 (0.0168)
DIF×Insured	−0.0050** (0.0023)			
FT×Insured		−0.0625** (0.0264)		
Transparency×Insured			−0.0340*** (0.0113)	
Disclosure×Insured				0.2608** (0.1310)
DIF	−0.0067 (0.0072)			
FT		0.0269 (0.0204)		
Transparency			−0.0311*** (0.0058)	
Disclosure				0.0187 (0.0460)
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	25,710	36,724	36,724	36,337
R-squared	0.335	0.291	0.292	0.294

Notes: *DIF* refers to the Digital Inclusive Finance Index and *FT* refers to the FinTech Pilot Policy; *Transparency* refers to the annual rating of accounting disclosure of listed companies by the Shanghai and Shenzhen Stock Exchanges, which is categorized into four grades of A, B, C, and D, and is assigned the values of 4, 3, 2, and 1. *Disclosure* refers to the corporate earnings management, and the larger the value is, the lower the level of corporate disclosure is.

may weaken shareholder litigation's disciplining effect and lower financial reporting quality (Chen et al., 2016), greater transparency helps investors make informed decisions, mitigating credit mismatch (Duong et al., 2024). Table 8, Columns (3) and (4) show that the interaction term between D&O insurance and the grades of accounting disclosure is statistically negative, while its interaction with corporate earnings management is positive, confirming that higher disclosure quality reduces credit mismatch. By mitigating information asymmetry, enhanced disclosure reduces the perceived risk of firms (He et al., 2022), making credit providers less likely to interpret D&O insurance as a risk signal, thereby reducing its adverse impact on credit mismatch.

5. Conclusion

This study finds that D&O insurance exacerbates credit mismatch, and this effect is driven by credit providers' discriminatory perception rather than managerial opportunistic behavior. Specifically, credit providers interpret the purchase of D&O insurance as a risk signal, leading to higher credit costs for firms with initially high credit expenses. Furthermore, the impact of D&O insurance on credit mismatch is more pronounced among non-state-owned firms, firms with smaller supervisory boards, and firms with lower institutional shareholding. Lastly, we find that digital technology adoption and corporate information disclosure help mitigate credit mismatch. From the policy perspective, our results highlight the need for regulators to strengthen the confidence of credit providers and investors in governance-enhancing tools like D&O insurance. Additionally, our findings provide theoretical support for promoting digital technology adoption and encouraging firms to mitigate credit mismatch. Our study capture mismatch from the financing cost perspective. However, credit mismatch is a multidimensional concept. Future research could explore alternative measures that may capture other characteristics, such as capital structure mismatch (Bai et al., 2020), to provide a more comprehensive understanding of the impact of D&O insurance on credit mismatches.

CRedit authorship contribution statement

Jing Wen: Writing – original draft, Visualization, Investigation, Formal analysis. **Xin Zhang:** Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Lizhen Wang:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix

Table A1
Balance test of the nearest neighbor matching.

Variables	Unmatched	Mean		Bias (%)	Reduce bias (%)	T-test	
		Treated	Control			T	P>T
Size	U	22.9320	22.0630	64.1		44.04	0.000
	M	22.9310	22.9060	1.8	97.1	0.84	0.398
Lev	U	0.4891	0.4495	19.9		12.48	0.000
	M	0.4889	0.4896	−0.4	98.2	−0.17	0.863
ROA	U	0.0265	0.0317	−7.9		−5.00	0.000
	M	0.0266	0.0258	1.2	84.7	0.56	0.577
Growth	U	0.3379	0.3735	−3.5		−2.15	0.031
	M	0.3381	0.3377	0.0	98.7	0.02	0.982
Board	U	2.2661	2.2598	3.5		2.16	0.031
	M	2.2660	2.2623	2.0	41.3	0.96	0.338
Dual	U	0.2120	0.2426	−7.3		−4.52	0.000
	M	0.2121	0.2152	−0.8	89.7	−0.37	0.715
FirmAge	U	2.5518	2.2469	50.5		31.07	0.000
	M	2.5515	2.5595	−1.3	97.4	−0.65	0.517
Top5	U	0.5252	0.5178	4.6		3.05	0.002
	M	0.5252	0.5213	2.5	46.2	1.16	0.246

(continued on next page)

Table A1 (continued)

Variables	Unmatched	Mean		Bias (%)	Reduce bias (%)	T-test	
	Matched	Treated	Control			T	P>T
Q	U	2.2404	2.5445	−17.6		−10.59	0.000
	M	2.2407	2.2431	−0.1	99.2	−0.07	0.948
Indep	U	0.3759	0.3691	12.6		7.99	0.000
	M	0.3759	0.3764	−0.9	92.5	−0.43	0.665
INST	U	0.4973	0.4565	17.0		10.93	0.000
	M	0.4973	0.4906	2.8	83.6	1.35	0.178
Mshare	U	0.0682	0.0979	−19.2		−11.20	0.000
	M	0.0683	0.0690	−0.4	97.7	−0.23	0.817
SA	U	−3.8795	−3.7626	−41.4		−27.56	0.000
	M	−3.8794	−3.8867	2.6	93.8	1.22	0.223
bank	U	0.0535	0.0825	−11.5		−6.77	0.000
	M	0.0535	0.0543	−0.3	97.4	−0.16	0.875

Notes: In the second column, U refers to the sample before employing the PSM, while M denotes the matched sample after applying the PSM.

Table A2

Balance test of the radius matching.

Variables	Unmatched	Mean		Bias (%)	Reduce bias (%)	T-test	
	Matched	Treated	Control			T	P>T
Size	U	22.9320	22.0630	64.1		44.04	0.000
	M	22.9310	22.9070	1.8	97.2	0.81	0.416
Lev	U	0.4891	0.4495	19.9		12.48	0.000
	M	0.4889	0.4895	−0.3	98.5	−0.14	0.888
ROA	U	0.0265	0.0317	−7.9		−5.00	0.000
	M	0.0266	0.0259	1.0	87.3	0.46	0.646
Growth	U	0.3379	0.3735	−3.5		−2.15	0.031
	M	0.3381	0.3411	−0.3	91.7	−0.14	0.887
Board	U	2.2661	2.2598	3.5		2.16	0.031
	M	2.2660	2.2637	1.3	62.2	0.62	0.538
Dual	U	0.2120	0.2426	−7.3		−4.52	0.000
	M	0.2121	0.2168	−1.1	84.4	−0.55	0.582
FirmAge	U	2.5518	2.2469	50.5		31.07	0.000
	M	2.5515	2.5533	−0.3	99.4	−0.14	0.885
Top5	U	0.5252	0.5178	4.6		3.05	0.002
	M	0.5252	0.5229	1.4	68.8	0.67	0.502
Q	U	2.2404	2.5445	−17.6		−10.59	0.000
	M	2.2407	2.2579	−1.0	94.3	−0.48	0.632
Indep	U	0.3759	0.3691	12.6		7.99	0.000
	M	0.3759	0.3763	−0.7	94.1	−0.34	0.733
INST	U	0.4973	0.4565	17.0		10.93	0.000
	M	0.4973	0.4935	1.6	90.8	0.76	0.448
Mshare	U	0.0682	0.0979	−19.2		−11.20	0.000
	M	0.0683	0.0688	−0.4	98.0	−0.20	0.840
SA	U	−3.8795	−3.7626	−41.4		−27.56	0.000
	M	−3.8794	−3.8853	2.1	95.0	0.99	0.321
bank	U	0.0535	0.0825	−11.5		−6.77	0.000
	M	0.0535	0.0543	−0.3	97.3	−0.16	0.869

Notes: In the second column, U refers to the sample before employing the PSM, while M denotes the matched sample after applying the PSM.

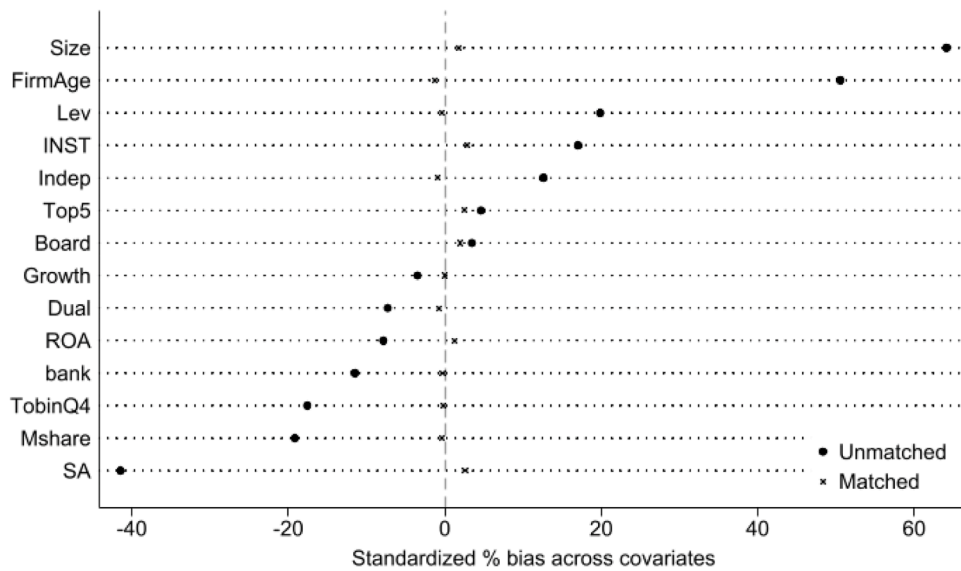


Fig. A1. Distribution of variables before and after nearest neighbor matching.

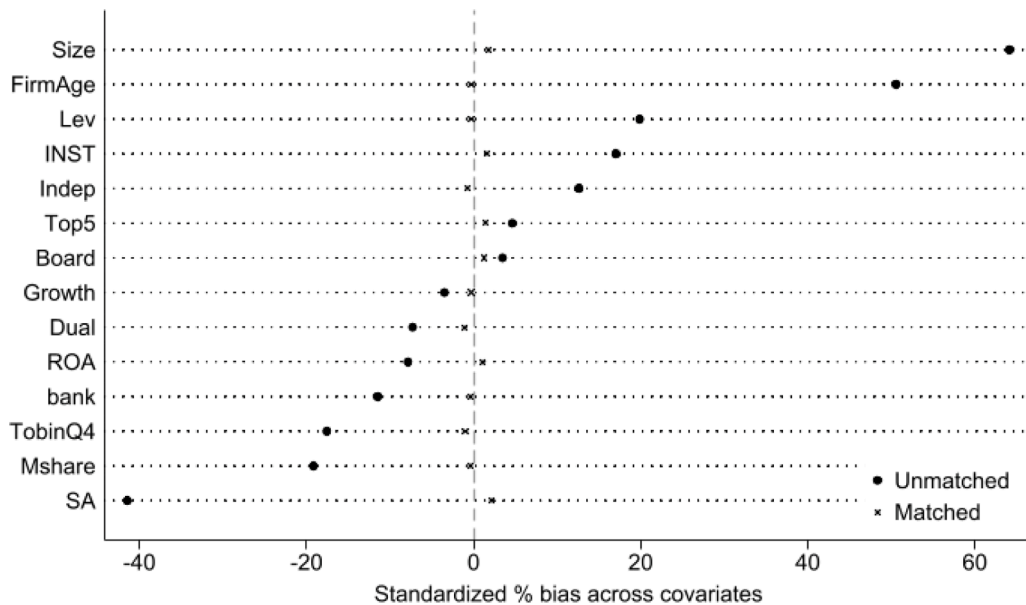


Fig. A2. Distribution of variables before and after radius matching.

Data availability

Data will be made available on request.

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