Research on the impact of equity pledge loans on financial distress and forecasting ability--Based on the "Factor-Logit" model

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Abstract. China has taken many steps in recent years to improve capital market oversight to guarantee the market's steady and sound growth. One of the most important strategies is to apply ST and *ST warnings to listed corporations that are operating in an unhealthy manner. At the same time, stock pledges are typically preferred by listed company shareholders as a convenient and effective financing option. This study selects financial and corporate governance variables, builds "factor-logit" analysis models to compare the prediction ability, and focuses on pertinent data of equity pledges involving the controlling shareholders of A-share listed companies in Shanghai and Shenzhen from 2003 to 2023. The findings indicate a negative relationship between the controlling shareholder's equity pledge actions and the likelihood of financial difficulties during the next three years. At the same time, the addition of equity pledge data has in fact increased the prediction's accuracy of financial hardship. This finding can give external lenders more precise investment information and has practical consequences for reducing financial crises.

Keywords: equity-pledged loans, financial distress, predictive capacity, "factor-logit" models.

1. Introduction

Recently, China's listed non-financial companies have had worse financial health. The average score for financial security of A-share companies fell 2.61% to 55.57 in 2023. Since 2024, some poorly-run listed firms have been labeled ST or *ST. So, accurate and timely financial distress forecasts are crucial now. Many businesses now raise money by pledging stocks.

Non-financial listed companies are affected by equity-pledged loans in two ways: they get more funding, and shareholders work harder to keep their power. But in China, major shareholders can take advantage if there's no good oversight. The question is: Does adding equity pledge loans improve financial distress prediction?

Past studies focused on how equity pledge loans affect management and the economy, not on financial crises or predictions. Modern financial distress prediction models use AI and include various fields. Scholars keep improving these models by adding new factors, but they haven't explored equity pledges much in this context.

As a result, this study first makes a simple model to predict financial trouble using governance and financial info. Then, it adds the equity pledge variable to create a "factor-logit" model to compare prediction power. The study also looks at how equity pledges relate to financial trouble by focusing on the variable's sign.

This study sees how equity pledge financing predicts business financial troubles. It helps find, prevent, and manage risks early. In unequal info markets, investors often lack good investment info. By adding equity pledge funding to prediction models, this study helps investors more accurately. It uses the equity pledge ratio to show how pledging affects finances. This makes the model more accurate and helps investors understand risks better.

2. Literature review

2.1. Projections of financial distress

The evolution of financial distress prediction models started with Fitzpatrick in 1932 using a single financial ratio [61]. Smith and Winakor (1935) predicted bankruptcy with ratios, followed by Merwin (1942) predicting it six years early. Hickman (1958) studied firms with debt, and Beaver (1966) found cash flow to debt ratio was best [55]. Altman (1968) created the MDA model with multiple ratios for bankruptcy prediction, later improving it to the Z-Score model with 22 ratios, then the Zeta model in 1977 [54]. Ohlson (1980) used the Logit model, Zmijewski (1984) used the Probit model [69]. In the 1990s, AI models like artificial neural networks, support vector machines, Random Forests, and Long-Term Memory Networks gained popularity. Hybrid models for financial distress prediction emerged and rapidly developed in the 21st century.[68] [71] [70] [65]

The choice of financial distress variables has expanded. Beaver (1966) first used financial variables for prediction [55]. Many scholars use financial indicators to build predictive models [69] [54], with some emphasizing independent indicators (Harmer, 1983) or specific ones like operating cash flow (Charitou et al., 2014) [62] [56]. Non-financial factors, like corporate governance, are also important, especially for small firms with incomplete data (Hayden, 2003; Maltz, 2003) [63] [67]. Poorly run firms may manipulate financial information (Chen Shou et al., 2015) [4]. Fulfilling CSR is linked to lower financial distress (Zhu & Xu, 2015) and the above studies suggest that non-financial variables are shown to improve the accuracy of prediction models [53].

In summary, financial distress prediction models have improved a lot. But most recent research focuses on model innovation and mainly uses financial indicators. Not many studies look at non-financial factors, and scholars haven't paid much attention to how equity pledge loans affect financial distress predictions. To see how equity pledge loans can improve predictions, this study adds them to the models.

2.2. Equity Pledge Loan

There are two motives for controlling shareholders to make equity pledge loans. genuine needs like company development or personal finances, or self-serving motives. Pledging can solve liquidity issues and bring external monitoring, possibly improving governance [48] [30]. However, when share prices fall, shareholders might manipulate financials to stabilize prices and keep control [9]. This can widen interest gaps and create agency problems, leading to potential misuse of power and harm to the company's long-term interests [48]. Equity pledges may also bring risks like control transfer and leverage, affecting operational effectiveness. [2]

Equity pledges have pros and cons. Wang Li (2024) found they prevent control loss and boost firm performance, with benefits like better market cap management, more M&A, higher dividends, and new issuances [34]. Wang, Bin, et al. (2013) agree this for private firms [33]. However, Gao Lanfang (2002) says they widen control-cash flow gaps, encouraging undue benefits and damaging the company [9]. Hao Xiangchao et al. (2013) found pledges hurt performance due to voting rights encroachment and weakened cash flow rights [12]. There's also a risk of cash flow issues and asset transfer by controlling shareholders (Claessens et al., 2000; Faccio et al., 2001) [58]. Li Laifang (2005) sees pledges as a quick money return method [20]. Li Yongwei (2007) and Zheng Guojian (2014) say controlling shareholders manipulate funds through capital appropriation and related transactions [24] [25]. Hao et al. (2009) and Huang (2014) argue pledges show funding issues, increasing incentives for misuse and surplus management problems [13] [17].

Currently, scholars focus on the impacts and governance of equity pledge loans. Dong and Zuo (2024) look at how ownership-control separation affects firm economy after pledges [7]. He et al. (2022) study pledges under tight monetary policy, focusing on pledge ratio, power use, and legal violations [15]. Li and Yang (2020) explore the economic effects of pledges [23]. Wang Zhimin (2020) offers suggestions on regulating equity pledging for financing [39]. Li Jubo et al. (2019) studied pledges' impact on corporate governance, performance, and risk [22]. Jin Ruolin et al. (2019)

comprehensively analyzed pledge causes, short-term effects, audit fees, and capital market impacts [19].

Equity pledge loans help businesses with money and boost their value, but they can also cause problems like asset misuse by owners. These loans affect a business in many ways, including its capital, risks, and management. This study aims to see if equity pledge loan data can help predict future financial risks for businesses and make prediction models more accurate.

3. Research hypotheses

Businesses can use equity-pledged loans for money. But pledging equity can hurt other shareholders and cause management problems. It's tough to see the link between these loans and businesses, but financial trouble and these loans are linked.

On one hand, equity pledges can help enterprises avoid financial crises by addressing short-term capital needs, improving liquidity, and promoting business expansion. Qi Zhihan (2024) notes pledges let shareholders keep equity while temporarily transferring rights to the pledgor [30]. Wang Li (2024) found pledges help manage market value, with more M&A, higher dividends, more stock issuance, and fewer share reductions [34]. Qiang, Guoling, and Feng (2024) say pledges improve corporate governance and ESG performance by making information more transparent and reducing mismanagement [31].

Equity pledging can weaken a business's finances and lead to misuse of resources. Zhu Wenting (2024) found firms with pledges have poorer accounting information quality [52]. Yang, Y.J. and Yang, Y.M. (2024) argue pledges by controlling shareholders harm ESG performance [44]. Liu Yun's (2023) study shows pledges hurt firm performance, with larger pledges leading to more pronounced declines [28].

This study looks at the pros and cons of equity pledge loans for businesses' long-term financial stability. Equity pledge lending is linked to company governance and finance decisions. It can both help and hurt businesses financially. So, this study suggests adding equity pledge loans to financial hardship prediction models can make them more accurate. Based on this, the paper proposes a hypothesis:

H1: Other things being equal, information on equity-pledged loans improves the predictive power of financial distress prediction models.

H1a: Other things being equal, the higher the equity pledge ratio the lower the likelihood that the firm is in financial distress.

H1b: Other things being equal, the higher the equity pledge ratio the higher the likelihood that the firm is in financial distress.

4. Research design

4.1. Sample selection and data sources

This study, from 2003–2023, looks at firms in Shanghai and Shenzhen A-share markets with financial trouble (STs). It screens out non-financial firms that have been around for more than three years. Then, it matches non-ST firms with ST firms based on industry, asset size, with a ratio of 1 ST firm to 3 non-ST firms.

For two years in a row, ST enterprises' net profits have shown losses. The study uses financial and equity pledge data from three years before they were labeled ST or not, removing outliers. This study used a 1% truncation method to preprocess all continuous variables to lessen the possible negative effects of outliers on the outcomes of regression analysis. In China, ST and *ST are warning labels for company risks, showing financial health. So, in this study, ST companies are considered in financial trouble.

Financial indicators are key when predicting financial trouble. This article first makes a simple prediction model using financial data. Then, it adds the equity pledge loan variable to make a

comparison model. This helps see how the equity pledge loan affects prediction accuracy. The study used 6,830 businesses' financial info. Table 1 shows the exact definitions.

Table 1. Variable Definition Table

Variable type	variable name	Variable Definition
implicit variable	ST	Listed companies that are ST or *ST are marked as 1, otherwise 0
independent variable	S1	Ratio of the number of shares pledged by controlling shareholders to the total number of shares during the year
	P1	Existence of controlling shareholders' equity pledge, marked as 1, otherwise 0
financial variable	CuR	current asset
	QR	Quick ratio = quick assets/current liabilities
	CaR	Capital adequacy ratio = capital/risk assets
	DA	Gearing ratio = liabilities/assets
	DE	depreciation
	LCD	Long-term capital gearing
	ROA	Net profit / average balance of total assets
	GP	Gross Profit = Operating Revenue - Operating Costs
	EPSG	EPS growth rate
Corporate governance capacity variables	CB	Convertible bond issue size
	BI	Proportion of independent directors
	CD	Distributed cash dividend, marked as 1, otherwise 0
	SOE	Nature of ownership, with state-owned companies taking the value of 1, otherwise 0

4.2. Financial distress forecasting model

In this paper, we refer to the studies of Han, Liyan, and Li Lei (2010) and Wang, Xiuli et al. (2017), and adopt the factor-Logit regression model to assess whether the information on pledged loans can enhance the prediction ability of corporate financial distress [11] [37]. With the variable xi (i=1, 2, 3..... k.... n), there are n in total:

$$\begin{cases} x_1 = a_{11} f_1 + a_{12} f_2 + \cdots + a_{1m} f_m + \varepsilon_1 \\ x_2 = a_{21} f_1 + a_{22} f_2 + \cdots + a_{2m} f_m + \varepsilon_2 \\ x_3 = a_{31} f_1 + a_{32} f_2 + \cdots + a_{3m} f_m + \varepsilon_3 \end{cases} \tag{1}$$

Simplification gives X = AF + ε, where:

$$A = \begin{bmatrix} a_{11} a_{12} \cdots a_{1m} \\ a_{21} a_{22} \cdots a_{2m} \\ \vdots \quad \vdots \quad \ddots \quad \vdots \\ a_{n1} a_{n2} \cdots a_{nm} \end{bmatrix} = (A_1, A_2, \cdots A_n) \tag{2}$$

The Logit model takes the following form.

$$p = p(Y = 1) = f(\beta_i, \quad x_i), \quad i = 1,2,3 \ldots k \tag{3}$$

$$\theta(p) = \text{Logit}(p) = \ln(p/p-1) = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon \tag{4}$$

$$P = \frac{e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon}}{1 + e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon}} \tag{5}$$

P denotes the probability that a firm will be in financial distress. If p > 0.5, the firm is more likely to face financial distress. If p ≤ 0.5, it's more likely to be financially stable.

To solve the problem of multicollinearity, rregarding Han, Liyan and Li Lei (2010) and Wang, Zhitao (2020), this paper introduces factor analysis into the regression model, and constructs a "factor-logit regression" model [11] [40]. The model is:

$$P_{i,t} = \frac{1}{1 + a_0 + a_1 pledge_{i,t-3} + \sum^{k} control_{i,t-3} + \varphi_{i,t-3}} \quad (6)$$

$p_{i,t}$ is the probability that firm i is in financial distress in year t.

4.3. Measurement of the predictive power of models

The ROC curve is a visual method for evaluating the efficacy of a binary classification model. The AUC value reflects the ability of the model to distinguish between the two categories, and the higher the AUC value, the better the model performance. The range of the AUC is from 0 to 1, and the higher value indicates the better model performance. In this paper, we refer to Beaver and Yu Lang to measure the predictive ability of the Logit model by the ROC curve [55][45].

4.4. Descriptive statistics

Descriptive statistics are shown in Table 2. To avoid outlier effects, this paper reports the statistical results after winsorisation and the data for each variable are from the first three years of ST/non-ST. About 1/3 of firms pledge equity (P1 mean=0.340), further confirming the prevalence of equity pledging. The mean value of S1 is 33.802, which would adversely affect the firms' finances once the share price falls below the close-out line. Debt and profitability are key indicators in financial distress prediction, the selection of variables in this paper has a theoretical basis and the mean performance is normal [54] [55] [56].

Table 2. Results of Descriptive Statistics

Var	N	Mean	Sd
S1	6830	33.802	14.673
P1	6830	0.340	0.474
CB	6830	0.743	0.610
BI	6830	36.997	5.702
CD	6830	0.281	0.450
SOE	6830	0.359	0.480
CuR	6830	2.549	3.145
QR	6830	2.054	2.904
CaR	6830	0.940	2.003
DA	6830	0.432	0.228
DE	6830	1.739	11.449
LCD	6830	0.119	0.307
ROA	6830	0.022	0.106
GP	6830	0.265	0.194
EPSG	6830	0.038	2.483

4.5. Factor analysis

Before factor analysis, we test the variables to see if they're suitable. We use the KMO test and Bartlett's test, with results in Tables 3 and 4. The KMO test checks how well variables are related. A KMO value over 0.5 is good for factor analysis, and 0.7 or higher is even better.

Table 3. KMO statistics

Variable	kmo
CB	0.7084
BI	0.6557
CD	0.7311
SOE	0.7172
CuR	0.7138
QR	0.6992
CaR	0.9429
DA	0.8425
DE	0.7615
LCD	0.7606
ROA	0.7694
GP	0.8562
EPSG	0.8306
Overall	0.7768

Bartlett's test checks if a set of variables are related. If the p-value is low (like below 0.05), it means the variables are related and factor analysis is suitable.

Table 4. Bartlett's test of sphericity

Bartlett's test of sphericity	approximate chi-square (math.)	43817.9957
	Df	78
	P-value	0.000

The KMO test result (0.7768) and small p-value (0.000) from Bartlett's test show that the variables are well-suited for factor analysis. We then found principal components for financial variables (Table 5) and combined financial & corporate governance variables (Table 6).

Table 5. Total Explainable Variance

(Math.) factor	eigenvalue (math.)	Explainable variance (%)	Cumulative variance contribution (%)
F1	3.68840	0.4098	0.4098
F2	1.39825	0.1554	0.5652
F3	1.00456	0.1116	0.6768

Table 6. Total Explainable Variance

factor	eigenvalue	Explainable variance (%)	Cumulative variance contribution (%)
FF1	3.82877	0.2945	0.2945
FF2	1.46796	0.1129	0.4074
FF3	1.31866	0.1014	0.5089
FF4	1.03001	0.0792	0.5881
FF5	1.00045	0.0761	0.6642

5. Analysis of empirical results

5.1. Analysis of main regression results

This study uses factor analysis and logit models to predict financial distress. Principal component factors derived from the analysis of financial variables alone form the basis of Model 1, while those derived from the analysis of corporate governance and financial variables form the basis of Model 2, and equity pledge variables are combined with these principal component factors in Model 3. Model 3 improves prediction, showing equity pledges are useful. S1 (-0.014) is significant, supporting H1 and H1a.

Table 7. Main regression results

Var	Model1	Model2	Model3 (Add S1)	Model3 (Add P1)
P1				.129
S1			-0.014***	
F1	-1.365***			
F2	1.648***			
F3	-0.456***			
FF1		-1.372***	-1.388***	-1.372***
FF2		1.070***	1.102***	1.085***
FF3		1.294***	1.214***	1.287***
FF4		-0.612***	-0.588***	-.605***
FF5		-0.071	-0.158***	-.068
cons	95.292***	127.166***	131.187***	131.59***
IND&YEAR	containment	containment	containment	containment
Pseudo-R2	0.3893	0.3984	0.4008	0.3987
ROC	0.8873	0.8919	0.8930	0.8922

Note: * indicates P<0.1, ** indicates P<0.05, *** indicates P<0.01.

5.2. Robustness tests

1. Change in the measurement of financial distress

This paper uses Altman's Z-Score to measure financial distress. Higher Z means less distress, defining Z > 50% score as 0 and vice versa as 1. The results in Tables 8 show that after the change in the financial distress metrics, the ROC values of Model3 are all better than those of Model2, S1's coefficient (0.009) is significant, supporting H1 and H1b.

Table 8. Regression Results for Changing the Measure of Financial Distress

Var	Modle1	Modle2	Modle3 (Add S1)	Modle3 (Add P1)
P1				.068***
S1			.031***	
F1	-3.983***			
F2	.313***			
F3	.542***			
FF1		-4.077***	-4.123***	-4.070***
FF2		-.461***	-.524***	-.448***
FF3		.708***	.931***	.705***
FF4		.312***	.267***	.317***
FF5		.323***	.545***	.324***
cons	74.914***	91.86***	87.55***	94.16***
IND&YEAR	containment	containment	containment	containment
Pseudo-R2	0.4343	0.4368	0.4487	0.4369
ROC	0.9056	0.9062	0.9109	0.9063

Note: * indicates P<0.1, ** indicates P<0.05, *** indicates P<0.01.

2. Using PSM to control endogeneity problems

By re-matching the samples that perform cross-sectional data based on year and industry, the PSM is utilized to produce a fresh sample of similar data. First, the control and treatment groups are separated based on whether the proportion of equity pledges (S1) is greater than 50. A 1:1 nearest neighbor matching approach was then used to match. Model 1 has 88.69% accuracy, while Model 3 has 89.17 %and 89.18%. S1's coefficient (-0.295) is significant, supporting H1 and H1a after fixing endogeneity.

Table 9. PS M regression results

Var	Modle1	Modle2	Modle3 (Add S1)	Modle3 (Add P1)
P1				.130
S1			-.295**	
F1	-1.330***			
F2	1.677***			
F3	-.449***			
FF1		-1.348***	-1.355***	-1.348***
FF2		1.089***	1.104***	1.105***
FF3		1.302***	1.277***	1.296***
FF4		-.609***	-.601***	-.601***
FF5		-.069	-.094*	-.066***
IND&YEAR	containment	containment	containment	containment
cons	96.283***	127.754***	130.239***	132.261***
Pseudo-R2	0.3883	0.3972	0.3981	0.3976
ROC	0.8869	0.8915	0.8918	0.8917

Note: * indicates P<0.1, ** indicates P<0.05, *** indicates P<0.01.

3. One-period lagged variables

In order to ensure the robustness of the results and avoid the error caused by lagging on the regression results, this paper lags the existence of controlling shareholders' equity pledge (P1) and the controlling shareholders' equity pledge ratio (S1) by one period, as shown in Table 10.The results show that the ROC value of Modle3 is significantly higher than that of Modle2, and the coefficient of S1 is -0.021, which is significant at the 1% level and satisfies H1 and H1a.

Table 10. Regression results for variables with one period of lagging

Var	Model1	Model2	Model3 (Add S1)	Model3 (Add P1)
P1				.129
S1			-0.021***	
F1	-1.365***			
F2	1.648***			
F3	-0.456***			
FF1		-1.372***	-1.580***	-1.580***
FF2		1.070***	1.380***	1.357***
FF3		1.294***	1.561***	1.552***
FF4		-0.612***	-.858***	-.846***
FF5		-0.071	-.0721	-.0735
cons	95.292***	127.166***	160.246***	139.937***
IND&YEAR	containment	containment	containment	containment
Pseudo-R2	0.3893	0.3984	0.4817	0.3987
ROC	0.8873	0.8919	0.9294	0.9219

Note: * indicates P<0.1, ** indicates P<0.05, *** indicates P<0.01.

6. Conclusions and recommendations

Research on the economic consequences of equity pledging behaviour has not been comprehensive enough, and there is a particular lack of research linking it to the predictive ability of firms in financial distress. Currently, academics mainly explore the impact of equity pledges on firm value, but the conclusions obtained are not uniform.

This study looks at how corporate financial trouble relates to promises made by controlling shareholders. It first uses traditional financial factors to predict financial distress. Then, it adds equity

pledge behavior to see if this improves predictions. It also checks how equity pledge percentages affect financial distress. The study shows that when controlling shareholders pledge stock, it reduces a company's chance of financial trouble in the next three years. Adding equity pledge data to the prediction model makes it more accurate. Tests confirm these results are reliable.

In summary, controlling shareholders' equity pledges are not only a means for enterprises to raise funds, but may also play an important role in the financial stability of enterprises and in predicting future financial risks. The extent and effect of this role may vary in different corporate contexts and needs to be comprehensively assessed in the context of specific situations.

In this regard, the paper makes the following recommendations:

Firsely, Enterprises considering equity pledges should watch out for macroeconomic policies to avoid risks. They should also improve risk management, communicate with creditors, and disclose information clearly.

Secondly, controlling shareholders should use pledged funds for business, not personal use, and avoid over-reliance on pledges to prevent financial risks.

Thirdly, Enterprises should improve their shareholding structure by methods like capital increase, share transfer, and incentives. Diversifying equity can weaken controlling shareholders' influence, give others more power, and improve equity liquidity. Bringing in strategic investors can also strengthen capital and competitiveness, and limit controlling shareholders' actions.

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