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Digital Transformation, Inefficient Investments and the Risk of a Stock Price Crash

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Abstract: Digital transformation is increasingly becoming an inevitable choice for the high-quality development of enterprises, so how will the digital transformation of enterprises affect their stock price crash risk? The article takes the A-share listed enterprises in Shanghai and Shenzhen from 2012 to 2022 as a sample, and the results obtained by empirical tests show that (1) the digital transformation of enterprises can reduce the risk of stock price crash and has a long-term nature; (2) the digital transformation of enterprises can reduce the risk of stock price crash by reducing the inefficient investment of the enterprises, which is mainly the problem of under-investment; (3) the digital transformation of enterprises with different property rights nature, quality of internal control, and institutional investors' shareholding have different impacts on the risk of stock price collapse when enterprises undergo digital transformation. The findings of this paper can provide a basis for enterprises to make decisions on important investment strategies in the process of digital transformation.

1. Introduction

The reports of the 19th and 20th CPC National Congresses have included the integration of digital economy and real economy in the national "14th Five-Year Plan", which shows that digital economy has become the direction of future economic development. According to the China Digital Economy Development Report (2022) released by the China Academy of Information and Communications Technology, the scale of China's digital economy will reach 45.5 trillion yuan in 2021, accounting for 39.8% of China's GDP, and the proportion is expected to exceed 50% by 2025. Different forms of digital economy have penetrated into all areas of the economy and society, constantly changing and upgrading the mode of production and operation of enterprises, and promoting digital transformation and empowering real business is an inevitable choice for enterprises to improve their competitiveness and realize high-quality development. General Secretary published an important article in the second issue of "seeking truth" in 2022, "continue to strengthen and optimize China's digital economy", which clearly pointed out that it is necessary to "promote the in-depth integration of digital technology and the real economy, empower the transformation and upgrading of traditional industries, and give birth to new industries, new business forms and new modes, and continue to strengthen and optimize China's digital economy".

From this, it can be seen that digital transformation has become a necessary path for the transformation and upgrading of enterprises and high-quality development, and it is also an important action issue that has attracted extensive attention from the government, all walks of life and the academic field in recent years.

The phenomenon of stock price crash from the firm's perspective is the phenomenon that the stock price of a listed company falls rapidly without any warning. (Callen J L et al., 2015)[1], (Kim et al., 2014)[2] define the risk of stock price crash as the phenomenon of extreme negative fluctuations in the distribution of the stock's returns. It has been argued in the literature that there are two main reasons for the formation of stock price crash risk: firstly, there is information asymmetry between the company and the investors information asymmetry makes the investors unable to know the real operating situation of the company may be deceived by false financial information leading to the existence of a bubble in the stock price. (Bleck A et al., 2007) [3]argued that managers have incentives to over-invest and in order to ensure that the project is not interfered with by the investors. They will hide this information as project losses continue to grow, which will eventually be detected by the market, triggering a large drop in the share price. China's capital market started late, and compared with mature capital markets abroad, sharp rises and falls are more common, and the risk of stock price crashes is greater. Through the above analysis, it can be argued that digital transformation will reduce the cost of obtaining information from stakeholders, leading to a reduction in the hiding of unfavourable information by firms; change the organisational structure of firms and improve the level of internal control; and adapt to the external environment of firms to mitigate the impact of environmental uncertainty faced by firms, thus reducing share price volatility. This leads to hypothesis H1.

H1: Other things being equal, digitization of firms is effective in reducing the risk of stock price collapse.

Enterprise value is the present value of existing assets created by prior investment and expected cash flows created by future investment, the conflict of interest specific to the scope of corporate investment is inefficient investment behaviour. Based on the various disadvantages of inefficient investment, Titman.S found that over-investment and market returns are significantly negatively correlated, the capital market for the more serious agency problems of over-investment in enterprises to show a negative market response. (Xu et al., 2015)[4] pointed out that corporate over-investment increases the risk of share price collapse, in which the agency conflict between shareholders and managers rather than managerial overconfidence is the main reason for the positive correlation between the two.

Digital transformation can help enterprises achieve high-quality development and enhance enterprise value. The key to the digital transformation of enterprises is the application of digital technology, and through the transformation of advanced technology and its big data analysis capabilities, it will further improve the enterprise's business model, help enterprises make faster and more accurate decisions, reduce non-efficient investment, thus creating more value and achieving high-quality development of enterprises (Verhoef et al., 2021)[5]. (Kohtamki et al., 2020)[6] argue that enterprises must further improve their service capabilities while undergoing digital transformation, and that the combination of the two can be more effective in achieving business goals and improving business performance. So, can corporate digital transformation reduce the risk of stock price collapse through the path of reducing corporate inefficient investment? Based on this, this paper proposes hypothesis H2.

H2: The digitisation of corporations can mitigate the risk of a stock price collapse by reducing the extent of inefficient corporate investment.

2. Research design

2.1. Data sources and processing

The present study employs a sample of China's A-share listed companies from 2012 to 2022. In the process of data aggregation, the samples are processed as follows: (1) Financial industry companies are excluded;(2) Years in which the stocks are ST and PT are excluded;(3) Samples with missing financial data and comprehensive attention indexes are excluded;(4) In order to exclude the effect of outliers, continuous variables are subjected to 1% and Winsorize shrinkage at the 99% level. Finally, a total of 26217 firm-level annual observations are obtained. The data were obtained from the Cathay Pacific database, which is referred to hereinafter as CSMAR.

2.2. Variable measurement

2.2.1. Stock crash index

This paper draws on past literature (Xu et al., 2015)[4] to adopt the following methodology to measure the risk of stock price movements. The first step in the analysis is to conduct a series of regressions in each year. The dependent variable in these regressions is the weekly return on stock i. The independent variable is the weekly return on stock i. In particular, in order to ensure the availability of financial data and to minimise the forward-looking bias, we examine the period from May of one year to April of the following year as the sample year.

$$R_{i,k} = \beta_0 + \beta_1 R_{m,k-2} + \beta_2 R_{m,k-1} + \beta_3 R_{m,k} + \beta_4 R_{m,k+1} + \beta_5 R_{m,k+2} + \varepsilon_{i,k} \tag{1}$$

The return on stock i in week k, denoted by $R_{i,k}$, is defined as the return on investment in stock i, considering reinvestment of cash dividends. The average market return on all A-share stocks in week k, denoted by Rm,k, is the weighted average of the returns on all stocks in the market, with the weights being the market capitalisations of each stock. The residual term of the above regression can be used to compute the idiosyncratic return of stock i in week k, denoted by $\omega_{i,k}$. This can be computed using equation:

$$\omega_{i,k} = \ln(1+\varepsilon_{i,k}) \tag{2}$$

Secondly, the following metrics are constructed based on $\omega_{i,k}$. Downside volatility (Duvol) can be computed using equation:

$$Duvol_{i,k} = \log\{[(n_u - 1)\sum^{Down}\omega_{i,k}^2]/[(n_d - 1)\sum^{Up}\omega_{i,k}^2]\} \tag{3}$$

The Down (Up) designation represents the set of samples where the weekly unique return of stock i is less than (greater than) or equal to the annual average return, while nu (nd) denotes the number of weeks where $\omega_{i,k}$ is greater than (less than) the annual average return. The greater the Duvol, the more left-skewed the distribution of returns is, and the greater the risk of a stock price crash.

The negative conditional skewness of future returns (Ncskew) can be computed using equation:

$$Ncskew_{i,k} = -[n(n-1)^{\frac{3}{2}}\sum\omega_{i,k}^3]/[(n-1)(n-2)(\sum\omega_{i,k}^2)^{\frac{3}{2}}] \tag{4}$$

The number of trading weeks per year for stock i, denoted by n, is a key factor in determining the severity of negative skewness. A larger Ncskew value indicates a greater likelihood of a stock price collapse.

2.2.2. Inefficient investment (INE)

This paper employs the methodology proposed by (Richardson ,2006)[7] to regress the lagged terms of firm growth (Growth), gearing (Lev), cash holdings (Cash), years on market (Age), firm size (Size), stock return (Return), and new investment expenditures (INV) with controls for industry and year. The residuals are then analysed to identify instances of firm over- or under-investment. The regression model includes controls for industry and year to account for any potential confounding effects. The residuals, which represent the difference between the actual and predicted values, are then analysed to identify instances of over- or under-investment. Residuals greater than 0 indicate over-investment, while residuals less than 0 indicate under-investment. The residuals of the regression, which are greater than 0, represent enterprise over-investment (OIE), while residuals less than 0 represent enterprise under-investment (UIE). The absolute value of the residuals of the regression is then taken to represent the inefficient investment (INE) of the enterprise. It should be noted, however, that this measure is a negative measure of corporate investment efficiency. That is to say, when the absolute value of the regression residuals is larger, the lower the corporate investment efficiency. The regression model is as follows:

$$INV_{it} = \beta_0 + \beta_1 Growth_{it-1} + \beta_2 Lev_{it-1} + \beta_3 Cash_{it-1} + \beta_4 Age_{it-1} + \beta_5 Size_{it-1} + \beta_6 \text{Re}turn_{it-1} + \beta_7 INV_{it-1} + \sum Industry + \sum year + \varepsilon_{it} \quad (5)$$

In particular, new investment expenditures (INV) are expressed as cash paid for fixed assets, intangible assets and other long-lived assets, net of proceeds from the disposal of fixed assets, intangible assets and other long-lived assets, divided by total assets at the outset. Corporate growth (Growth) is measured using the growth rate of the main business. Gearing ratio (Lev) is measured by dividing liabilities by total assets. Cash holdings (Cash) are measured by dividing cash and cash equivalents by total assets. Age is measured using the difference between the current year and the year of listing plus one logarithm. Size is measured using the natural logarithm of total assets. Return on equity is measured using the annualised return on individual shares (taking into account reinvestment of cash dividends). Industry and Year are measured using dummy variables.

3. Results and discussion

3.1. Benchmark regression

This paper presents the results of a fixed effects model, selected on the basis of the findings of Hausman's test, which is employed to test hypothesis H1 and to correct for heteroskedasticity by means of clustering robust standard errors. The regression model is as follows:

$$Ncskew_{i,t} = \alpha + \beta\ DTA_{i,t} + \gamma\ Control_{i,t} + \sum Industry + \sum year + \varepsilon_{it} \quad (6)$$

Table 1 presents the regression results of model. Column (1) presents the regression results of firm digitisation on the risk of share price collapse. In the regression of column (1), the regression coefficient of DTA is -0.000986 and is significant at the 1% level, indicating that the higher the degree of enterprise digitisation, the lower the likelihood of the risk of enterprise share price collapse. In columns (2) and (3), the independent variable enterprise digitisation is lagged by one period and two periods, respectively. From the regression results, it can be seen that the regression

coefficient of the independent variable after one period is lagged is -0.000818 and is significant at the 1% level of significance. After lagging the independent variable by two periods, the regression coefficient becomes -0.00129 and is significant at the 1% level. It can be observed that enterprise digitalisation is negatively correlated with the risk of stock price collapse. Furthermore, the effect of enterprise digitalisation on the risk of stock price collapse is persistent, which corroborates the hypothesis H1.

Table 1: Multiple regression results.

	(1)	(2)	(3)
	Ncskew	Ncskew	Ncskew
DTA	-0.000986***		
	(-3.69)		
L.DTA		-0.000818***	
		(-3.21)	
L2.DTA			-0.00129***
			(-4.00)
Ind	Control	Control	Control
Year	Control	Control	Control
_cons	-0.536	-0.475	-0.876
	(-1.26)	(-0.93)	(-1.49)
N	26217	20839	17264
R2	0.031	0.034	0.040
adj. R2	0.030	0.033	0.038

3.2. Empirical analysis of impact mechanisms

This paper posits that corporate digitisation can mitigate the risk of share price collapse by reducing the inefficiencies associated with investment decisions. The regression results in Table 2 column (2) of the table demonstrate that the regression coefficient of enterprise digitisation (DTA) on the degree of inefficient investment (INE) is -0.0000502 and is significant at the 5% level. At the 1% level of significance, the results indicate that enterprise digitisation (DTA) has a negative effect on the degree of inefficient investment (INE). This implies that the higher the level of digitisation of an enterprise, the lower the level of its inefficient investment. Column (3) indicates that the regression coefficients of digital transformation and the degree of inefficient investment are -0.000863 and 0.468, respectively, and are significant at the 1% significance level. This suggests that inefficient investment plays a partially mediating role in the relationship between digital transformation and the risk of stock price collapse. Corporate digital transformation can mitigate share price crash risk by reducing the degree of corporate inefficient investment. Hypothesis H2 is thus tested.The role played by under-investment and over-investment in inefficient investment in influencing digital transformation and stock price crash risk is further analysed. The results are shown in Table 3, columns (2) and (3) show that digital transformation has an inverse relationship with under-investment,digital transformation attenuates under-investment in firms with a regression coefficient of -0.0000659, and is significant at the 5% significance level. Column (3) shows that the regression coefficients of digital transformation and under-investment are -0.000904 and 0.347, respectively, and both are significant at the 1% significance level, suggesting that under-investment partially mediates the relationship between digital transformation and the risk of stock price collapse. Column (4) shows that the mediating role of over-investment is not significant. In summary, firms digital transformation can reduce share price crash risk by reducing firms under-

investment.

The authors posit that agency problems are a significant contributor to stock price crash risk. They argue that management may conceal unfavorable information from external stakeholders to advance their self-interest, which may include opportunistic behaviors such as monetary compensation, on-the-job spending, career concerns, and empire building. Once this negative information reaches a threshold that cannot be concealed, it may suddenly emerge, leading to a stock price crash.

Table 2: Mediating effects.

	(1)	(2)	(3)
	Ncskew	INE	Ncskew
DTA	-0.000986***	-0.0000502**	-0.000963***
	(-3.69)	(-2.08)	(-3.60)
INE			0.468***
			(4.30)
Indep	0.0354	0.00939	0.0310
	(0.24)	(0.94)	(0.21)
Ind	Control	Control	Control
Year	Control	Control	Control
_cons	-0.536	-0.154***	-0.464
	(-1.26)	(-4.47)	(-1.09)
N	26217	26217	26217
R2	0.031	0.089	0.032
adj. R2	0.030	0.088	0.031

Table 3: Over-investment and Under-investment.

	(1)	(2)	(3)	(4)
	OIE	Ncskew	UIE	Ncskew
DTA	-0.000179**		-0.0000659*	
	(-2.52)		(-1.88)	
OIE		-0.0122		
		(-0.14)		
UIV				0.353***
				(3.07)
Ind	Control	Control	Control	Control
Year	Control	Control	Control	Control
_cons	-0.478***	-0.175	-0.502***	-0.390
	(-3.64)	(-0.30)	(-6.73)	(-0.68)
N	11056	11056	14349	14349
R2	0.079	0.033	0.059	0.034
adj. R2	0.076	0.030	0.056	0.032
F	7.043	6.990	11.02	9.425

3.3. Robustness check

To ensure the reliability of the conclusions, this paper adopts the method of replacing the explanatory variables with the explained variables to conduct the robustness test.

(1) Replace the explanatory variables

In order to ensure the reliability of the findings, the regression is re-run by choosing the ratio of upward and downward volatility of returns (DUVOL) as a measure of stock price crash risk with reference to the existing literature. As shown in column (1) of Table 4, the coefficient of DTA is -0.00109, which is significant at the 0.1% level, indicating that there is a negative and significant relationship between Digital Transformation (DTA) and the risk of stock price collapse (DUVOL), thus supporting the previous hypothesis H1, and the regression results are robust.

(2) Substitution of explanatory variables

As there is still no unified standard for the definition of enterprise digitalisation, various scholars use different ways to measure the degree of enterprise digital transformation. Therefore, the approach of Chenyu Zhao et al. is adopted to redefine the degree of enterprise digital transformation and regress it. The results, as shown in the column of Table 4(2), show that the coefficient of DTB is -0.000698, which is significant at the 0.1% level, indicating that after replacing the way of defining the degree of corporate digitalisation, it is still negatively related to the risk of stock price collapse, supporting hypothesis H1 in the previous paper, and the regression results are robust.

(3) Deletion of crash years

Due to the sharp fluctuations in the external economic environment in 2015 and 2016, which may have an impact on the results, we choose to delete the data of these two years to re-run the regression. From column (3) of Table 4, the coefficient of DTA is -0.000837 and is significant at the 1% level, indicating that the regression results are robust after removing the years of abnormal stock price volatility.

Table 4: Robustness Tests.

	(1)	(2)	(3)
	Duvol	Ncskew	Ncskew
DTA	-0.00109***		-0.000837**
	(-4.91)		(-2.84)
DTB		-0.000698***	0.581***
		(-4.06)	(3.95)
Ind	Control	Control	Control
Year	Control	Control	Control
_cons	0.373	-0.323	-0.798
	(1.45)	(-0.77)	(-1.18)
N	26217	26217	24,439
R2	0.041	0.033	0.033
adj.R2	0.040	0.032	0.034

3.4. Heterogeneity analysis

3.4.1. Nature of property rights

Due to the difference in the nature of the enterprise's shareholding, it will also be affected by different factors when making investment decisions, so the impact of enterprise digitisation on the enterprise's investment efficiency will be different under different types of enterprises. Therefore, this paper investigates the impact of enterprise digitisation on the risk of share price collapse in SOEs and non-SOEs by grouping them according to the nature of equity, which is defined as SOE=1 for SOEs and SOE=0 for non-SOEs. The regression results, as shown in columns (1) and (2) of Table 5, show that the regression coefficient of the impact of the degree of digital transformation (DTA) on the risk of share price collapse is -0.0 in the non-SOEs. The regression coefficient for the effect of risk is -0.00129 and significant at the 1% statistical level, while state-owned firms are significant only at the 5% statistical level. This evidence suggests that digital transformation is more likely to reduce the risk of firms' share price collapse in non-state-owned firms compared to state-owned firms.

Table 5: Heterogeneity test.

	(1)	(2)	(3)	(4)	(5)	(6)
	Ncskew	**Ncskew**	**Ncskew**	**Ncskew**	**Ncskew**	**Ncskew**
	SOE=1	SOE=0	DIB=1	DIB=0	INST=1	INST=0
DTA	-0.00179**	-0.00129***	-0.00164***	-0.000189	-0.00167***	-0.000796
	(-2.28)	(-3.56)	(-4.25)	(-0.17)	(-4.23)	(-1.15)
Ind	Control	Control	Control	Control	Control	Control
Year	Control	Control	Control	Control	Control	Control
_cons	0.411	-0.860	-0.0959	0.0468	-0.272	1.498
	(0.62)	(-1.81)	(-0.11)	(0.05)	(-0.61)	(1.38)
N	8985	17232	20550	5666	19663	6554
R2	0.040	0.037	0.047	0.036	0.038	0.048
adj.R2	0.036	0.035	0.043	0.033	0.032	0.044

3.4.2. Internal control

In this paper, the DIB internal control index is employed to assess the extent of internal control within firms. This index is divided into two groups, with the 25th percentile serving as the threshold. The group with strong internal control effectiveness is recorded as DIB=1, while the remainder is recorded as DIB=0. The regression results, as shown in columns (3) and (4) of Table 5, indicate that the degree of digital transformation (DTA) exerts a significant effect on the risk of stock price collapse in firms with high internal control quality. However, this effect is not observed in firms with low internal control quality. Table 5, column 4, indicates that the impact of digital transformation (DTA) on the risk of stock price decline in firms with high internal control quality is -0.00164, a statistically significant result at the 1% level. In contrast, this relationship is not significant in firms with low internal control quality. This indicates that the various advantages that digital transformation confers upon firms necessitate the implementation of robust internal governance in order for the mitigating effect on share price crash risk to be fully realised.

3.4.3. Institutional investor shareholding

The proportion of institutional investor shareholding is calculated by dividing the number of shares held by institutional investors by the total number of shares in the firm's float. This figure is then divided into two groups using the 25th percentile as the threshold. The group with a large proportion of institutional investor shareholding is denoted as INST = 1, while the remaining is denoted as INST = 0. The regression the results, as shown in columns (5) and (6) of Table 5, indicate that the impact of the degree of digital transformation (DTA) has a regression coefficient of -0.00167 and is statistically significant at the 1% level on the impact of share price crash risk. However, this relationship is not observed in firms with low institutional investor shareholding. This indicates that digital transformation exerts a more pronounced negative influence on share price collapse in firms with a substantial institutional investor shareholding.

4. Results and discussion

To study the impact of enterprise digitisation on the risk of share price collapse, the following conclusions are drawn from the analysis: (1) enterprise digitisation is significantly negatively correlated with the risk of share price collapse, i.e., the higher the degree of digital transformation, the lower the risk of share price collapse; (2) heterogeneity analysis shows that: the inhibitory effect of digitisation on the risk of share price collapse of state-owned enterprises is insignificant compared with that of non-state-owned enterprises;(3) From the internal perspective, the negative effect of digital transformation on share price collapse is more significant in firms with good internal control; (4) From the external perspective, the negative effect of digital transformation on share price collapse is more significant in firms with a high proportion of institutional investor shareholding; (5) Mechanism tests show that the degree of inefficient investment in firms plays an intermediary role in the transmission path, and that digital transformation can reduce share price collapse by mitigating the problem of under-investment in firms, compared with over-investment; (6) Mechanism tests show that the degree of inefficient investment in firms plays a mediating role in the conduction path.

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