Impact of Digital Transformation on Enterprise Resilience during Public Crises in the Yangtze River Delta Region of China

Xi Zhao[1*], Qian Tang[1], Huili Wu[1], Jing Xie[2]

[1]School of Economics and Management, Hefei University, Anhui, Hefei, 230601, China
[2]School of Humanities and Arts, Shanghai Lixin University of Accounting and Finance, Shanghai, 201209, China

[*]Correspondence: zhaoxi@hfuu.edu.cn

Abstract. Based on the financial data of 731 listed companies in the Yangtze River Delta region from 2016 to 2022, this study measures the degree of enterprise digital transformation using the entropy weight TOPSIS method and constructs a PSM-DID model to explore the impact of digital transformation on the resilience of listed companies in the Yangtze River Delta region during public crises. It finds that digital transformation helps improve the resilience of enterprises in the studied period, and companies with better digital transformation tend to take better measures to reduce losses during public crises. Based on these findings, this study provides valuable insights for academia, business practice and policy-making in digital transformation and enterprise resilience.

Keywords: Digital transformation; PSM-DID model; public crises; enterprise resilience; Yangtze River Delta Region

1 Introduction

Digital transformation of enterprises is significant in accelerating the construction of an innovative country and improving the national competitiveness. In an increasingly uncertain global environment, understanding how digital transformation can make businesses more resilient is essential for long-term survival and success. However, in recent years, global and local public crises occur frequently, bringing various impacts on socio-economic development. Public crisis is caused in the process of social operation, due to natural disasters and failure of social systems, which may bring challenges to the digital transformation of enterprises[1].

The extant research studied the correlation between digital transformation and enterprise resilience. Li et al. (2022) found that digital transformation has played a positive role in the resilience of enterprises. Through digital transformation, enterprises can find more new opportunities and resources, alleviate the problem of resource shortage caused by the crisis, and improve the adaptability under the public crisis[2]. Scholars emphasized that enterprises' digital transformation is the key to ensure the continuity

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of business operations, maintaining their competitive advantage and enhancing resilience during public crises[3-4]. Secondly, reserach on mechanism how digital transformation affects enterprise resilience has been attracted attention in recent years. For example, Wang and Zhao (2023) discussed the mechanism and influence of the digital transformation of agricultural and forestry enterprises on enterprises resilience under risk events by fixed effect model, and pointed out that digitalization can significantly enhance the enterprises resilience under the public crisis, and the long-term effect is stronger than the short-term effect[5]. To promote digital transformation and enterprise resilience, Li and Sun(2022) proposed to break the limitation of time and space through social, organizational and institutional empowerment of digital technology, realize the reshaping of governance structure, improve the response speed of enterprises to public crises, and reduce risks and losses[6]. Zhou and Yang (2022) addressed to enhance enterprise digital transformation through internal control to restrain the risk of stock price crash under public crisis [7].

Although a number of literature studied the impact of digital transformation on enterprise resilience in different sectors, only few study focused on listed companies in the Yangtze River Delta region of China. As a hub for technological innovation in China, the Yangtze River Delta is at the forefront of digital transformation. Studying this region can offer a glimpse into the future of how technology can enhance business continuity and adaptability. Therefore, based on the financial data of 731 listed companies in this region from 2016 to 2022, this paper tries to analyze the impact of digital transformation on the enterprises resilience of listed company under the public crisis. Findings from such a study can offer valuable insights for academia, business practice, and policy-making.

2 Methodology and Data Source

2.1 Data Source and Variable Selection

This study selects the period of 2016-2022 as the research time range. The year 2020 is considered as the year when the COVID-19 epidemic occurs, which represents the start of a public crisis. Considering the particularity of financial indicators for ST, PT, and financial enterprises, we exclude ST, PT, and financial listed company as well as enterprises with key missing data. A total of 731 listed companies in the Yangtze River Delta region and 9503 observations were selected as research sample. The data sourced from the CSMAR database, the Grand Tide Information Network[1], and annual reports of listed companies. Considering the impact of outliers on statistical inference, in order to eliminate the differences in characteristic attributes such as properties, dimensions, and orders of magnitude between different variables, this paper performs Z-standardization on the data. The variable definitions are shown in Table 1.

[1] The China Securities Regulatory Commission has designated the Grand Tide Information Network as the official website for the disclosure of information by listed companies. It was established in 1995, and is one of the earliest professional securities information websites in China.

The explained variable (dependent variable) is Net Profit (NP), which is the profit obtained by the listed company after deducting all the costs and expenses. Its fluctuation illustrates the level of enterprise resilience during the studied period.

The explanatory variable (independent variable) is Digital Transformation (DT). Refering to the study by Wu et al.[8], the degree of enterprise digital transformation is measured by the frequency of keywords related to digital transformation in the enterprise annual report. First of all, we caculated the frequency sum of keywords related to digital transformation in each enterprise's annual report from 2016 to 2019. A comprehensive evaluation index system for digital transformation was established from five dimensions, including artificial intelligence technology, blockchain technology, cloud computing technology, big data technology and digital technology application. Then the entropy TOPSIS method is used to comprehensively evaluate the degree of digital transformation of enterprises. The top 1/4 enterprises with the highest comprehensive score were considered as enterprises with high-level digital transformation (DT=1, a total of 183 enterprises), and the other enterprises were considered as enterprises with relatively low-level digital transformation (DT=0, a total of 548 enterprises).

Control variables were selected based on existing research, including Equity cash flow (Ecf), Company cash flow (Ccf), Proportion of shares held by institutional investors(prop), Size of listed companies (Size), Assets Return (Ar), Return on assets (ROA), Total asset growth rate (Tagr), Return on equity (ROE), Asset liability ratio (Alr), and ownership concentration (Oc). Considering the impact of audit quality on enterprises, whether auditors come from the Big four accounting firms (Big4)[2] is included as a control variable.

2.2 PSM-DID Model

Propensity Score Matching (PSM) is a method that processes research data into "data from a randomized controlled experiment", aiming to reduce data bias and the interference of confounding factors. Difference-in-Differences (DID) mainly measures the effect of an intervention based on the changes before and after the event time point between the control group and the treatment group. In order to test the impact of digital transformation on the resilience of listed company in the Yangtze River Delta region under the background of public crisis, the following PSM-DID model is constructed:

$$Y_{it} = \alpha_0 + \alpha_1 DID_{it} + \alpha_2 DT_{it} + \alpha_3 time_{it} + \alpha_4 Controls_{it} + \varepsilon_{it} \quad (1)$$

$$DID_{it} = DT_{it} \times time_{it} \quad (2)$$

Among them, i represents the selected enterprise, t represents the year, Y represents the net profit of the explained variable. DID represents the interaction term between

[2] The Big four accounting firms include PricewaterhouseCoopers(PwC), Deloitte Touche Tohmatsu Limited (Deloitte), Ernst & Young Global Limited (EY), and KPMG International Cooperative(KPMG).

DT and the time variable. Controls is the above mentioned control variables. ε_{it} indicates the random error term. $\alpha_1$is used to measure the degree of difference between enterprises with better and weaker digital transformation.

Table 1. Variable Definitions

Variable	Variable name	Variable symbol	variable-definition
Explained Variable	Net profit(RMB 100 million)	NP	Company net profit
	Time	Time	0 for 2016-2019, and 1 for 2020-2022
Explanatory Variable	Digital Transformation	DT	The top 1/4 enterprises with the highest comprehensive score as DT=1; the other enterprises as DT=0
	Equity cash flow	Ecf	Net profit- (total owner's equity) changes in the current period- (cash received from absorbing equity investment-cash paid from distributed dividends, profits or interest payments) + (monetary funds) changes in the current period
	Company cash flow	Ccf	Net profit + financial expenses- (total assets) current period + (monetary funds) current period- (Total liabilities) current period- (cash received from absorbing equity investment-cash from distributed dividends, profits or interest payments)
Controlled Variable	Return on assets	ROE	Corporate net profit / average net assets
	Size of listed companies（100 million）	Size	Scale of listed companies（100 million）
	Whether auditors come from the Big 4 accounting firms	Big4	The auditor from the Big Four accounting firm takes 1, otherwise take 0
	Assets Return（%）	Ar	(Total profit + financial expenses) / total assets
	Return on assets（%）	ROA	Net profit / total assets balance
	Total asset growth rate（%）	Tagr	(Total ending value of current period-Total initial value of current period) / (Total initial value of current period)
	Proportion of shares held by institutional investors（%）	prop	Total number of shares held by institutional investors/ total shares of listed companies(%)
	Asset liability ratio（%）	Alr	Total liabilities / Total assets
	ownership concentration（%）	Oc	The total shareholding ratio of the top ten shareholders of the enterprise

3 Empirical Research Results

3.1 Results of Descriptive Statistics

Descriptive statistics show the maximum values of the seven control variables, including equity cash flow, cash flow, listed companies, auditors from the big four accounting

firms, return on assets, total assets net profit and equity returns, are significantly different from the mean, exceeding three standard deviations, indicating that the data fluctuates greatly and there is a large gap between different enterprises. To be specific, the maximum standard deviation of the enterprise size was 582.1, and the data fluctuated the most among the 11 control variables. Compared with the changes in the financial data before and after the COVID-19 epidemic in 2020, the average net profit of enterprises till December 2019 was 597 million yuan, and the average net profit of enterprises till December 2022 was 522 million yuan. It has decreased by 12.56% compared to 2019. The corresponding standard deviation of net profit of enterprises increased from 20.46 before COVID-19 to 22.21 after the crisis, showing a widening trend. This indicates that under the impact of the public crisis, the overall profitability and stability of listed company have declined.

Table 2. PSM Parallel Hypothesis Test Results

Item	State	Experimental group	Control group	Standard-ization deviation (%)	Magnitude of standardized de-viation reduction (%)	*t* value	*p* value
ROE	Match before	-0.0554	0.0415	-9.5	63.4	-3.43	0.001
	Match after	-0.0469	-0.0115	-3.5		-1.23	0.220
Tagr	Match before	-0.0992	0.0744	-18.2	88.8	-6.17	0.000
	Match after	-0.0974	-0.0780	-2		-1.09	0.274
Ccf	Match before	0.0138	-0.0103	2.4	-70	0.85	0.394
	Match after	0.0002	0.04115	-4.1		-1.41	0.159
Ecf	Match before	0.0306	-0.0230	5.4	-100.7	1.90	0.058
	Match after	0.0323	0.1398	-10.8		-2.62	0.009
Ar	Match before	-0.0563	0.0422	-9.9	85.1	-3.49	0.000
	Match after	-0.0537	-0.0390	-1.5		-0.55	0.580
ROA	Match before	-0.0404	0.0303	-7.1	79.4	-2.50	0.012
	Match after	-0.0377	-0.0232	-1.5		-0.56	0.579
Size	Match before	0.0685	-0.0513	11.6	84.3	4.25	0.000
	Match after	0.0284	0.0472	-1.8		-0.60	0.547
Big4	Match before	0.0127	-0.0095	2.2	-167.5	0.78	0.433
	Match after	0.0080	0.0673	-5.9		-1.84	0.065
prop	Match before	-0.0152	0.0114	-2.7	18.2	-0.94	0.348
	Match after	-0.0189	0.0028	-2.2		-0.74	0.460
Alr	Match before	0.1026	-0.0770	18	88.5	6.38	0.000
	Match after	0.0958	0.0752	2.1		0.69	0.489
Oc	Match before	-0.1618	0.1213	-28.5	96.9	-10.12	0.000
	Match after	-0.1652	-0.1741	0.9		0.28	0.776

3.2 Resutls of PSM

Using logit regression to perform nearest neighbor matching with replacement at a 1:1 ratio, after propensity score matching, 2186 samples from the experimental group and 2908 samples from the control group were successfully matched, with a total of 5094 successful samples. 23 unsuccessful matched samples were removed. Table 2 shows the results of the PSM parallel hypothesis testing. The results illustrate that most of the absolute value of the standardized deviation after matching is less than 10% and the

standardized deviation decreases greatly, indicating that the matching results are acceptable and the matching results basically meet the prerequisite for analysis with DID.

3.3 Results of DID

Basic Regression Results. Based on the results of propensity score matching, net profit (NP) is selected as the dependent variable. The estimated results of the impact of digital transformation on corporate resilience in the context of COVID-19 are shown in Table 3.

Table 3. DID Model Results

Time	Item	Effect value Net profit (YUAN)	Standard error	*t* value	p value
Before	control group	-0.013			
	experimental group	-0.012			
	Diff(T – C)	0.002	0.022	0.08	0.940
After	control group	-0.004			
	experimental group	0.075			
	Diff(T – C)	0.078	0.039	2.02	0.043**
Diff-in-Diff		0.077	0.045	1.71	0.087*

R^2: 0.570， Adjust R^2: 0.569 * p<0.05 ** p<0.01

Before the outbreak of COVID-19 (time=0), the Diff effect value was 0.002, which was not significant (p> 0.05), indicating that there was no significant difference between the experimental group and the control group, which meets the parallel trend hypothesis. After the outbreak of COVID-19 (time=1), the Diff effect value was 0.078> 0 and showed a 5% level (p <0.05), meaning that the effect value of the experimental group was significantly higher than that of the control group. The effect value of Diff-in-Diff is 0.077> 0 and showed 10% significance (p <0.1), namely the DID regression coefficient 0.077 present 10% significant (p <0.1). It demonstrates that enterprise digital transformation can improve the enterprise resilience and reduce the negative impact of the public crisis, which supports the hypothesis.

Parallel Trend Test. The effect value of Diff(T-C) before the pandemic (Before) is 0.002, and its p-value is 0.940, which is greater than 0.1 and not statistically significant. This means that before the public crisis, the effect levels of the experimental group and the control group were essentially the same, showing no significant differences, thereby indicating that the parallel trends assumption is satisfied.

Robustness Test. (1) The effectiveness of the DID model. If the decline in business effect is not due to COVID-19, then the estimated results of the two-fold difference model will hold after changing the COVID-19 time. To this end, we adjusted the start time of COVID-19 forward and backward, so that the whole sample interval of the experiment fell before the real experiment (forward)) and after the real experiment

(backward), respectively, and then observed the estimation results of the new two-fold difference model. The results show that the coefficient of DID is no longer significant, indicating the conservatism of the results.

(2) Change the PSM matching method. The logit regression was used to match the ratio of 1:2,1:3 and 1:5. The results showed that the DID coefficient was still significantly positive, indicating the stability of the results.

4 Conclusion

Based on the bove analysis, the following conclusions are summed up. Firstly, this study results show that enterprise digital transformation is conducive to improving the resilience of listed company in public crisis in the Yangtze River Delta region, and enterprises with better digital transformation can take better measures to reduce their losses. This finding is consistant with previous literature, such as study from Zhang et al.[9] Therefore, it is necessary for the government to improve policies to strengthen digital infrastructure investment and promote the digital transformation of enterprises. It is also essential to encourage and support listed company to accelerate their digital transformation and promote enterprise resilience. By analyzing the impact of digital transformation on resilience in this region, other regions or countries can benchmark their progress and learn from the strategies employed in the Yangtze River Delta.

Secondly, compared with previous studies, this study further expands the data sources, and includes the control variables representing the unique characteristics of listed companies into the research model. It allows for a more accurate assessment of the impact of digital transformation on enterprise resilience. This helps to control for potential confounding factors and provides a clearer understanding of the relationship between digital transformation and resilience. Thus, it complements existing literature by offering new insights on the relationship between digital transformation and enterprise resilience, adding depth to the existing body of knowledge.

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