EMERGING MARKETS FINANCE AND TRADE
https://doi.org/10.1080/1540496X.2023.2247140

Routledge
Taylor & Francis Group

Digital Economy Development and Corporate Bankruptcy Risk: Based on the Perspective of Institutional Isomorphism

Jianmin Liu [a], Shichen Wang [a], Yude Xu [b], and Lingsha Cheng [c]

[a]School of Economics & Management, Nanchang University, Nanchang, Jiangxi, China; [b]Chinese Academy of Fiscal Sciences, Beijing, China; [c]Department of Accounting, Ningbo University, Ningbo, Zhejiang, China

ABSTRACT

Digital economy development gives birth to new market norms and competition rules, which push digital transformation and further form the legitimacy isomorphism effect to decrease corporate bankruptcy risk. Using a sample of Chinese listed firms from 2011 to 2019, this study investigated how digital economy development influences corporate bankruptcy risk. We observe a negative relationship between digital economy development and bankruptcy risk. This negative relationship is more pronounced in firms when the degree of digital transformation, managerial incentive and internal supervision is expected to be high.Additionally, the risk effect of digital economy is more pronounced for firms with more media coverage, lower urban wealth, industry competition, and better government governance. Our study has implications for research on the microeconomic consequences of digital economy development and the factors influencing corporate bankruptcy risk, providing empirical evidence for bankruptcy risk management in the digital economy era.

KEYWORDS

Digital economy; institutional isomorphism; bankruptcy risk; isomorphic effect; adaptive incentives

JEL

M10; O18

1. Introduction

The credit enhancement brought about by the economic society and the rise of the enterprise leverage ratio may rapidly increase the bankruptcy risk in some enterprises. Consequently, a considerable number of enterprises could face a dilemma of insolvency or even bankruptcy. Modern socialized division of labor and cooperation has led to unprecedented interdependence among various market entities. Enterprises with greater bankruptcy risk may experience a significant impact on upstream and downstream enterprises, leading to the spread of risk across different sectors. Furthermore, risk interlocks across different sectors may further boost systemic risk in the real economy and financial sectors. For example, the debt crisis of Evergrande, a famous listed real estate enterprise in China, triggered more than 20 listed companies to fall into a debt crisis within a year and eventually pushed up the bad debt rate in China's financial industry.

Recently, the rapid development of digital economy has brought new opportunities and challenges to businesses. On the one hand, traditional economy focuses on product production and operations, while digital economy focuses more on product use and service extension. In digital economy, production and consumption boundaries between participants are unclear, generating product-independent profits that increase corporate earnings (Goldfarb and Tucker 2019; Tussyadiah and Pesonen 2016). On the other hand, the profits arising from digital economy can also reduce the price markup of products, which decrease the profits of traditional enterprises and threaten their survival and development (Zervas, Proserpio, and Byers 2017). As business forms and technologies of digital economy gradually replace the old models and technologies of traditional economy, new market norms and competition rules are formed. These changes induce

CONTACT Yude Xu xuyude352@sina.cn Chinese Academy of Fiscal Sciences, No. 28 Fucheng Road, Haidian District, Beijing 100142, China

enterprises to engage in new industries, business forms, and technologies, thus exacerbating the gap in gains between traditional and digital enterprises. Despite these benefits, if the firms fail to adapt to the development of digital economy, it may lead to a sharp drop in corporate profits and even business insolvency

According to an analysis of transaction cost economics (TCE), the growth of digital economy can lessen the information asymmetry between the two parties of a transaction, thereby lowering the external transaction cost (Dana and Orlov 2014). This can also lower the internal organizational costs of enterprises and possibly reduce their risk of going bankrupt. According to the New Institutionalism of Organizational Sociology, businesses must exhibit legitimacy isomorphic behavior, which means they must form adaptive incentive structures that conform to the new laws of competition.[1] The development of digital economy as an institutional environment for business decision-making gives birth to new market norms and competition rules, which will often conflict the old business model, method, and technology of enterprises. The 2021 Digital Transformation Index of Chinese Enterprises points out that some enterprises find it difficult to gain benefits in digital transformation because of their poor capacity for digitization and corporate governance. Businesses must create an adaptable incentive structure for the application of digital technologies; that is, enterprises must have a synthesis effect. Whether and how institutional isomorphism is produced, which may have an impact on the risk of business bankruptcy, is a new market norm and competitive rule generated by the expansion of the digital economy. Pertinent research has not received enough attention, and there is a dearth of theoretical and empirical studies on digital economy development and corporate bankruptcy risk, and even fewer studies on enterprise isomorphism.

This study examines the interplay between digital economy and corporate bankruptcy risk using a sample of listed Chinese companies from 2011 to 2019. There are two main reasons for examining listed Chinese firms only. First, the prevention and mitigation of systematic risk, especially corporate bankruptcy risk, is key to China's economic operations. Second, with the digital transformation and upgrade occurring in China since 2011, several Chinese enterprises that could not adapt to the emergence of new economies and technologies were eliminated. Thus, the risk of corporate bankruptcy has increased. However, little is known about how digital economy development affects the risk management of enterprises. This setting provides a natural experiment for gauging the effectiveness of digital economy.

This study contributes to existing literature in three ways. First, it enriches the literature on the economic consequences of digital economy development. Previous studies focused on the effects of digital economic development on the productivity and innovation capacity of firms (Goldfarb and Tucker 2019; Tussyadiah and Pesonen 2016), the construction of digital platforms (Branstetter and Kwon 2018; Goldfarb and Tucker 2019), and social income distribution (Acemoglu and Restrepo 2020; Lin and Wang 2017). This is the first study to examine the role of digital economy development in corporate bankruptcy risk. Second, this article expands and supplements research on the variables influencing bankruptcy risk and conventional financial theory. The impact of corporate tax avoidance and gender diversity among executives on bankruptcy risk have been studied previously (Cho et al. 2021; Dhawan, Ma, and Kim 2020). However, this paper – which is based on the digital economy model – expounds the study on the variables affecting bankruptcy risk and offers fresh insight on how to prevent and address systemic and corporate bankruptcy risks. Third, the literature on methods of measuring the development of digital economy has expanded. Previous research encountered various issues, including subjective bias and incomplete indicator coverage. This study examines the digital economy indicators from three perspectives based on prior assessment techniques: digital economy industry, digital economy platform and users, and digital economy innovation and transactions, which effectively improve the objectivity and integrity of the indicators. In empirical studies, the New Institutionalism of Organizational Sociology is quite uncommon. Internal and external adaptive incentive structures are empirically tested in this work to further organizational sociology's new institutionalism theory and empirical research.

2. Prior Literature and Hypotheses Development

Digital economy development is a critical trend in social technology and institutional arrangements (Hinings, Gegenhuber, and Greenwood 2018). It forms the operational basement, rules, and framework of the social operating system, contains new norms and competition rules, and poses legitimacy pressure on enterprises (Broekhuizen Thijs and Zhu 2021). Digital economy development is an institutional environment for business decision-making with the requirements for organizational reform, improvement of digital capacity building, and formation of an adaptive incentive structure for digital innovation. Digital economy gives rise to legitimacy isomorphism of enterprises, including normative isomorphism driven by new norms, mimetic isomorphism driven by new competition rules, and coercive isomorphism driven by digital resource suppliers.[2] First, normative isomorphism is regarded as a higher level of digitization that triggers the application and upgrade of new technologies. This forms professional standards and practice norms established by digitization, which ensures behaviors and products of enterprise to meet the new standards. Second, mimetic isomorphism is defined as a higher level of digitization that triggers the formation of new competition rules in the industry. Mimetic isomorphism pushes enterprises to improve their digital resources and capabilities in accordance with new competition rules, aiming to gain competitive advantage in supply-chain relationship management and increase production efficiency (Svahn, Mathiassen, and Lindgren 2017). Imitation is an important way for enterprises to enhance their competitiveness when their counterparts, especially industry leaders, have realized digital transformation. Third, coercive isomorphism refers to digital resource providers, such as government departments, financial institutions, platform enterprises, and other resource providers that tend to promote the formation of a digital economic environment. Enterprises are under pressure from the entities owned by these organizations. Normative, mimetic, and coercive isomorphisms help improve the information processing and management efficiency of enterprises and lead to the accumulation of competitive potential, which increases the inflow of future economic benefits to business. Therefore, the three isomorphisms can provide higher information efficiency (Balakrishnan et al. 2014), growth opportunities (Segal, Shaliastovich, and Yaron 2015), and expected value, thus reduce corporate bankruptcy risk in enterprises.

Digital economy can improve the information efficiency of enterprises. The normative isomorphism generated by digital economy can improve financial performance.Normative isomorphism significantly improves data processing and mining. Thus, enterprises can standardize and structure data coding, which makes it easier to improve the delivery and use efficiency of internal information and further reduce the degree of information asymmetry. Additionally, normative isomorphism helps enterprises master their operations and production status and improve access to funds. The mimetic isomorphism generated by digital economy improves the competitive advantage of small and medium enterprises in the industry. Leading companies in the industry can gain competitive advantage by accumulating a large amount of data on business processes, including product design, quality monitoring, market promotion, order sales, and terminal distribution. Digital economy can hasten mimetic isomorphism and create new competitive rules. That is, digital economy development enables other enterprises in the same industry to obtain massive, non-standardized, and unstructured data and further encode them into standardized and structured effective information to reduce the degree of information asymmetry between the two sides. Furthermore, enterprises can convert effective information into production information and use it to imitate the behaviors of industry leaders. This is important for narrowing the technological gap between them and industry leaders, thereby reducing competitive disadvantages and creating more development opportunities. The coercive isomorphism generated by the digital economy is beneficial for reducing the acquisition cost of digital elements and increasing the acquisition quantity of resources. Under different historical conditions of economic development, various factors including labor, capital, information, and technology, have become the primary factors of production.

With the gradual integration of digital technologies such as the Internet, artificial intelligence, and big data into the operation and management activities of enterprises, the acquisition cost and resource quantity of digital information elements have become some of the most important factors for the development of enterprises. Providers of digital resources provide structured and standardized digital information, whereas competitive and cooperative exchanges require mandatory standard organizational structures and processes. Coercive isomorphism can lower the acquisition cost of standardized digital information and provide more access to digital information resources, which can alleviate information asymmetry in market competition and bankruptcy risk in business processes.

The digital economy also provides enterprises with more growth opportunities. First, the normative isomorphism generated by the digital economy may help form adaptive incentive structures, obtain promising investment opportunities, and reduce investment risks. According to the S-curve law of Theory of Inventive Problem Solving (TRIZ), for enterprises that adopt old models and methods, new technologies are in an embryonic stage. This is manifested by low market demand, weak diffusion ability, and poor yield of new technological achievements. The investment efficiency of enterprises in new technology is related to the mechanism of resource allocation, cost of technology conversion, and destructiveness of the new technology, which mainly depends on the incentive structure to realize adaptability[3] Normative isomorphism enables enterprises to form competition rules and adaptive incentive structure in line with the degree of digital economy development. The investment in new technologies will make it easier for enterprises to achieve greater business success and lower bankruptcy risk. Second, the mimetic isomorphism generated by the digital economy may help enterprises reduce both trial-and-error costs and the risk of R&D failure. Mimetic isomorphism can carry out information analysis, grasp direction, and process optimization of peers' technological activities, especially for leading enterprises in the same industry, at a lower cost. The improvement of resource utilization can help enterprises gain more benefits, for example lower cost of trial and error, less R&D risk and bankruptcy risk. Third, the coercive isomorphism generated by the digital economy may make it easier for enterprises to build a cost advantage in competitive markets and reduce bankruptcy risk. Coercive isomorphism makes it easier for enterprises to gain trust from the providers of factor resources, meaning that enterprises can obtain factor resources such as capital, talent, and information at a relatively low price, thereby reducing operational risk related to bankruptcy risk.

The digital economy can add to the expected firm value. First, the normative isomorphism generated by the digital economy may bring about an added capital market valuation. It will inform the capital market that enterprises adapt to the new norms of digital economy development and consequently improve the capital market's confidence in the development prospects of enterprises to a certain extent. If the market holds a more positive expectation on the prospects of enterprises, it will improve its judgment of the expected value of the enterprise. This is important to attract the attention of external funds, increase cash flows, improve financial flexibility, and reduce bankruptcy risks. Second, the mimetic isomorphism generated by the digital economy may lead to the market's certainty expectation of firm value growth. Industry leaders demonstrate the effects of digital transformation. Imitating the technologies and norms of leaders usually reduces the trial-and-error costs of enterprises' transformation failures, enhances the probability of successful transformation, attracts the attention of more risk-averse investors, increases the flexibility of cash flow, and therefore reduces the risk of bankruptcy. Third, coercive isomorphism related to the digital economy increases the expected market value. If enterprises meet the isomorphic requirements of a digital factor provider, they can obtain lower prices for the digital factors. The lower price in the factor market will bring about a reduction in operating costs and an increase in future economic benefits, which will increase market expectations for the growth of firm value and therefore restrain bankruptcy risk. Thus, we develop the following hypothesis: Higher digital economy development is associated with lower corporate bankruptcy risk.

3. Data and Methods

3.1. Data Collection

The study used data on Chinese listed firms from 2011 to 2019. The samples were obtained from several sources. Stock and market return and accounting data for all non-financial companies were drawn from the China Stock Market and Accounting Research (CSMAR) database. The China Urban Statistical Yearbook, China Statistical Yearbook, and Peking University Digital Financial Inclusion Index of China provided original data to calculate the level of digital economy development. The sample excludes financial firms or those observations with missing data, resulting in 14,001 firm-year observations. The Winsorized mean of all continuous variables were obtained at intervals of 1% and 99%.

3.2. Variable Measurement and Research Design

3.2.1. Dependent Variable

The Z-score was used as the main proxy for corporate bankruptcy risk, following Altman (2000). The Z-score is calculated using the following equation:

$$Z\_score = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4 + 3.25 \quad (1)$$

where the variables are the ratio of working capital scaled by total assets (X_1), retained earnings divided by total assets (X_2), ratio of earnings before interest and tax scaled by total assets (X_3), and ratio of market value equity to book value of total liabilities (X_4). Higher values indicate a lower risk.

3.2.2. Variable of Interest

Referring to Bukht and Heeks (2018) definition of the digital economy, the study used principal component analysis to construct an index for the level of digital economy development (*digit*). It is composed of three primary and 13 secondary indicators. The index system covers the digital economy innovation and trading, digital industry, and digital economy platform features, as shown in Table 1. The index for the level of digital economy development is proxied by the first three principal components. Higher index values indicate a higher level of development in the digital economy.

3.2.3. Control Variables

The study controls for a wide array of regional economic development and firm features, including corporate governance and financial characteristics, that prior literature have shown

Table 1. Measurement index system of digital economy.

Primary Indicators	Secondary Indicators	Indicator attribute
Digital industrialization	The proportion of fixed assets owned by information transmission, computer services, and software industries.	+
	The proportion of employees in information transmission, computer services, and software industries.	+
Digital platform and user scale	Internet broadband access ports ratio.	+
	The natural logarithm of the number of websites.	+
	The natural logarithm of internet users.	+
	The natural logarithm of the number of domain names.	+
	Digital financial inclusion index.	+
	Mobile phone penetration rate.	+
	Proportion of enterprises with e-commerce trading activities.	+
Digital innovation and transaction	The natural logarithm of total volume of telecommunications services.	+
	Number of patents granted in the 5 G industry.	+
	Proportion of online sales in total sales of consumer goods.	+
	Software revenue.	+

to be related to the level of digital economy development (Liu, Chen, and Chou 2011). The regional-level variables include the level of regional economic development (*lnGDP*) and general budget expenditure (*lnGBE*). The firm-level variables include firm size (*Size*), return on assets (*ROA*), debt-to-equity ratio (*Equityratio*), sales growth (*Growth*), total asset turnover ratio (*ATO*), operating cash flow ratio (*Cashflow*), inventory to total assets ratio (*INV*), ownership structure (*SOE*), and listed years (*ListAge*).

3.2.4. Multivariate Analyses

To test the hypothesis, the digital economy's impact on corporate bankruptcy risk was estimated using the following OLS regression:

$$Z\_Score_{i,j,t} = \alpha_0 + \alpha_1 digit_{j,t-1} + \sum control + \delta_i + \delta_t + \delta_{it} + \varepsilon_{it} \quad (2)$$

where i represents the firm, j represents the province, and t represents the year. The dependent variable was proxied using Altman's (2000) Z_score. The variable of interest, *digit*, represents the level of digital economy development. To avoid simultaneity bias and strengthen the causality interpretation, the digital economy variable led by the lagged value (*t-1*) was used. *Control* is a matrix of the control variables described in Section 3.2.3. Meanwhile, δ_i, δ_t, and δ_{it} denote industry, year and industry × year fixed effects, respectively. ε_{it} is the error term. All the variables are defined in the Appendix. Robust standard errors adjusted for firm-level clustering and heteroskedasticity were used.

4. Results

4.1. Descriptive Statistics

Table 2 provides the summary statistics for the full sample (Panel A), as well as difference tests for the two subsamples based on the level of digital economy development (Panel B). The mean *Z_score* of 6.408 was obtained from a broad range, with a minimum value of 0.097 to a maximum

Table 2. Summary statistics.

Variables	Mean	Median	Min	Max	S.D.
Panel A: Summary statistics of the full sample					
Z_Score	6.408	3.829	0.097	49.79	7.856
digit	2.604	2.354	−1.493	8.005	2.316
Size	22.260	22.069	19.660	26.19	1.259
Growth	0.178	0.037	−0.574	3.52	0.429
Equityratio	1.125	0.697	−136.2	186.1	3.352
ROA	0.040	0.111	−0.398	0.222	0.062
ATO	0.666	0.000	0.053	2.902	0.418
Cashflow	0.047	0.573	−0.200	0.257	0.065
INV	0.141	0.117	0	0.772	0.111
SOE	0.354	0.045	0	1	0.478
ListAge	2.210	2.197	0.693	3.332	0.625
lnGDP	10.500	10.518	7.957	11.59	0.7
lnGBE	18.010	18.045	16.34	18.97	0.495

	High_digit		Low_digit		Difference tests
Variable	Mean	Median	Mean	Median	Median
Panel B: Summary statistics of two subgroups of the sample firms					
Z_Score	6.833	4.135	5.995	3.487	0.838***	0.648***

Notes: The table displays summary information for the full sample used in the main regression model (Panel A) as well as for subsamples based on the level of digital economy development (Panel). A firm is sorted into the High_digit group if *digit* is approximately the industry-year median *digit* of the whole sample, and into the Low_digit group if otherwise. Mean differences are tested by t-tests. Median differences were tested using the Wilcoxon rank-sum test. All continuous variables are winsorized at the top and bottom 1% level.

***, **, and * measure statistical significance at the 1%, 5% and 10% level, respectively.

value of 49.79. This suggests that the *Z_score* varies widely among firms in China. The average *digit* is 2.604, with a standard deviation of 2.316 and a median of 2.354. This result could be attributed to the difference in the development level of regionalized digital economies. Regarding the control variables, the average value of *Growth* is 0.178, indicating that Chinese businesses are still in the early stages of development. The mean *Equityratio* is 1.125, indicating that Chinese businesses have a sizable amount of debt financing. The means of *ROA*, *ATO*, *Cashflow*, and *INV* were 0.040, 0.666, 0.047, and 0.141, respectively. Their values are similar to those of previous studies (Chen et al. 2022).

The sample is divided into two groups according to the median development of the digital economy. The results of testing for differences in means and medians suggest a significant difference in corporate bankruptcy risk; firms in regions with lower levels of digital economy development have higher bankruptcy risk than firms in regions with a higher level of digital economy. This result preliminarily verifies the previous hypothesis.

4.2. Empirical Results

The results for Equation (2) are reported in Columns (1)–(5) of Table 3. In Column (1), the estimated coefficient on *digit*, that is, α_1 in Equation (2), without control variables and fixed effects, is positive and significant at the 5% level. In Column (2), *digit* in Equation (2) without fixed effects is significantly positively correlated with the *Z_score* at the 5% level. Columns (3) and (4) show Equation (2), with the year fixed effect and year-industry fixed effect,

Table 3. Results of basic regression.

Variable	(1)	(2)	(3)	(4)	(5)
digit	0.135**	0.186**	0.324***	0.245***	0.244***
	(2.37)	(2.42)	(3.96)	(2.99)	(2.94)
Size		−2.335***	−2.349***	−2.301***	−2.299***
		(−22.38)	(−22.74)	(−21.13)	(−20.73)
ROA		38.477***	38.185***	36.287***	35.892***
		(18.00)	(17.79)	(19.38)	(18.31)
Equityratio		−0.057**	−0.062**	−0.061***	−0.061***
		(−2.23)	(−2.37)	(−2.70)	(−2.73)
Growth		−0.494***	−0.517***	−0.559***	−0.609***
		(−3.06)	(−3.31)	(−3.64)	(−3.89)
SOE		−0.430*	−0.376	−0.297	−0.267
		(−1.71)	(−1.43)	(−1.14)	(−1.01)
ATO		−1.622***	−1.423***	−1.723***	−1.806***
		(−5.87)	(−5.19)	(−5.62)	(−5.79)
INV		−6.737***	−6.460***	−8.009***	−7.925***
		(−8.30)	(−8.05)	(−8.24)	(−7.99)
Cashflow		4.998***	4.851***	5.063***	5.528***
		(3.90)	(3.72)	(3.96)	(4.14)
ListAge		−0.661***	−0.614***	−0.814***	−0.807***
		(−3.39)	(−3.02)	(−4.27)	(−4.17)
lnGDP		−1.223***	−0.885**	−0.227	−0.202
		(−3.36)	(−1.99)	(−0.54)	(−0.47)
lnGBE		1.090**	0.399	−0.154	−0.179
		(2.04)	(0.57)	(−0.23)	(−0.26)
Constant	6.115***	53.230***	61.873***	64.917***	65.088***
	(32.73)	(7.29)	(6.72)	(7.29)	(7.08)
Year	NO	NO	YES	YES	YES
Industry	NO	NO	NO	YES	YES
Year × *Industry*	NO	NO	NO	NO	YES
N	14,001	14,001	14,001	14,001	14,001
R-squared	0.001	0.296	0.330	0.375	0.397

Notes: This table presents the interplay between the level of digital economy development (*digit*) and corporate bankruptcy risk (Z_score). The t-statistics in parentheses are computed based on standard errors clustered at firm level.

***, **, and * measure statistical significance at the 1%, 5% and, 10% level, respectively. See Appendix for the variable definitions.

respectively. The coefficient of *digit* is both positive and significant. Column (5) reports the results of Equation (2), controlling for all fixed effects. The correlation between *digit* and *Z_score* is positive and statistically significant at the 1% level. In terms of economic significance, the value of corporate bankruptcy risk with a one-unit increase in the level of the digital economy increases by 0.244 units, which is equivalent to 3.81% of the mean value of the *Z_score*. These findings strongly support the hypothesis. The coefficients of the control variables are generally consistent with those in prior literature. Specifically, the *Z_score* is negatively related to *Size, Equityratio, Growth, ATO, INV* and *ListAge*, while it is positively related to *ROA* and *Cashflow* in Column (5).

4.3. Robustness Tests

4.3.1. Omitted Variable Bias

The bankruptcy tendencies of enterprises will not only be affected by the development of digital economy, but also by the book-to-market ratio and the shareholding ratio of institutional investors. Therefore, this study adds the book-to-market and shareholding ratios of institutional investors as control variables to control for endogeneity problems arising from omitting variable bias. The results in Column (1) of Table 4 show that even if the omitted variable bias is considered, the coefficient on *digit* is still significantly positive, indicating that the findings are robust to omitted variables.

4.3.2. Instrumental Variable Estimation

It is possible that the key explanatory variable (*digit*) is correlated with an unobserved variable embedded in the error term, and that this unobservable variable may affect bankruptcy risk. Hence, these concerns were alleviated using the instrumental variables method.

Referring to Nunn and Qian (2014), the two alternative measures, geographical location and terrain features, are exogenous instrumental variables. First, we use the interaction term of the logarithm of the distance between the region of the corporate headquarters and Hangzhou City of China[4] and the logarithm of the stock of digitally transformed enterprises in each region as the first instrumental variable. The stock of digitally transformed enterprises of each region is calculated by summing the frequency of the keywords, such as artificial intelligence technology, block-chain technology, cloud computing technology, big data technology, and digital technology application in the annual report.[5] Second, we employ the interaction term of the terrain relief of each province and the logarithm of the stock of

Table 4. Results of the robustness tests.

Variable	Omitted variable bias	Instrumental variable estimation	Alternative proxy for bankruptcy risk	Alternative proxy for digital economy
digit	0.155*	0.579***	−.147***	
	(1.96)	(2.80)	(−4.05)	
digit2				.697***
				(3.02)
Constant	45.830***		−36.298***	65.189***
	(5.02)		(−7.78)	(7.10)
Control	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES
N	14,001	14,001	14,001	14,001
R-squared	0.436	0.260	.467	.397

Notes: Column (1) presents the results considering the omitted variable bias. Column (2) provides the results using the instrumental variable estimation. Columns (3) and (4) provide the results with an alternative measures of bankruptcy risk and digital economy development, respectively. The t-statistics in parentheses are computed based on standard errors clustered at the firm level.
***,**, and, * measure statistical significance at the 1%, 5% and, 10% level, respectively.

digitally transformed enterprises as an alternative measure for the second instrumental variable.[6]

The F-statistics of the first stage (unreported) are greater than the critical value of the rule of thumb 10, and the Kleibergen-Paap Wald rk F-statistics are significantly greater than the critical value at the 10% level, which rejects the null hypothesis of weak instrumental variables. Additionally, the p-value of the Hansen J statistic for the over-identification test result is 0.488. Hence, the null hypothesis that the instrumental variable satisfies exogeneity cannot be rejected. Column (2) of Table 4 presents the results for the second-stage regression of the digital economy's effect. It was observed that the coefficient of *digit* is positive and statistically significant at the 1% level, indicating that the main finding of the study remains robust to self-selection bias.

4.3.3. Alternative Proxy for Bankruptcy Risk

Following Ohlson (1980) and Asness, Frazzini, and Pedersen (2019), the *O-score* was used as an alternative measure of corporate bankruptcy risk. The *O-score* is calculated as follows:

$$\begin{aligned} O-Score = &-1.32-0.407size+6.03lev-1.43wc+0.0757cl \\ &-1.72lia-2.37roa-1.83sale+0.285pat-0.521\Delta ni/\Delta|ni| \end{aligned} \tag{3}$$

where independent variables include a wide array of financial characteristics and are defined or calculated as follows: *size* is the natural logarithm of total assets; *lev* is the debt-to-assets ratio; *wc* is the ratio of net working capital to total assets; *cl* is the ratio of current liabilities to current assets; *roa* is the ratio of net profit to total assets; *sale* is the ratio of operating income before discount to total assets; and Δni is the difference between the net profit of the current period and net profit of the previous period. The variable, *lia*, is one if the total liabilities exceed total assets and zero otherwise; *pat* equals one if the after-tax net profit of the enterprise in the first two years is negative and zero otherwise. A higher *O-score* indicates a higher bankruptcy risk. As shown in Column (3) of Table 4, *digit* is significantly positively correlated with *O-Score* at the 1% level regardless of the measure of bankruptcy risk.

4.3.4. Alternative Proxy for the Level of Digital Economy Development

The study applied dimensionless processing to the 13 indicators of digital economy development in Table 1, and then used the average value of all indicators as the second alternative measure (*digit*2). The results in Column (4) of Table 4 show that the coefficient of *digit* is positive and statistically significant at the 1% level. Hence, the main findings still hold regardless of the measure of digital economy used.

4.4. Additional Analyses

As discussed above, digital economy development reduces corporate bankruptcy risk by generating homogeneous behavior. Khurana (1999) noted that internal and external systems can format internal and external adaptive incentives and are beneficial for risk reduction. Hence, it was necessary to determine if the internal and external systems moderate the risk effects of digital economy.

4.4.1. Tests for the Moderating Roles of Internal Adaptive Motivation on the Risk Effect of Digital Economy

4.4.1.1. Moderating effect of digital transformation. Corporate digital transformation reflects the transformation and organizational change made by enterprises to adapt to digital economy development, aiming to meet the new norms formed by the digital economy, imitate the advantages of their peers in the same industry, and obtain digital resources. Hence, we focus on the moderating role of digital transformation.

Referring to the definition of digital transformation in the literature of Tu and He (2023), the keyword database was related to corporate digitization. The keywords were then added to the "jieba" Chinese lexical database in the Python software package. Based on the machine learning method, we analyzed the text of the "management discussion and analysis" segments in the annual reports and determined the frequency of occurrence of words related to corporate digitization. The level of digital transformation (*Transformation*) is defined as the logarithm of the frequency of occurrence. A higher *Transformation* value indicated a higher level of digital transformation. Furthermore, all firms in our sample are sorted into two groups based on their level of digital transformation. A firm is assigned to the High_Tran (Low_Tran) subgroup if its *Transformation* value is higher (lower) than the industry-year median. We re-estimated Equation (2) and reported the results in Columns (1) and (2) of Table 5. The coefficient of *digit* is positive and statistically significant only in the High_Tran group, suggesting a positive moderating effect of digital transformation on the relationship between the digital economy and bankruptcy risk.

4.4.1.2. The moderating effects of corporate governance. In enterprises, the ability of the organizational structure and governance mechanisms to mobilize resources is also directly related to digital economy development. Enterprises often form new business management processes and effective corporate governance by means of executive incentive and internal supervision. The aims are to promote collaboration between all the business units, enhance the coordination, management capacity, and resources of the organizational structure, and eventually adapt to the development of the digital economy. Therefore, we aim to understand the moderating roles of incentives and supervision mechanisms.

A subgroup analysis was used to examine the moderating roles of governance mechanisms, including managerial incentives and internal supervision. First, referring to Wu and Wu (2010), the levels of managerial incentives and internal supervision were evaluated. Managerial incentives (*Incentive*) are calculated as the logarithm of the total compensation of the sum of the top three salaries of directors, supervisors, and executives. We used principal component analysis for four unique attributes as proxies for the level of internal supervision (*Sup*). These attributes include the proportion of independent board directors, shareholdings of institutional shareholders, board size, and supervision size. Second, the subgroups were divided based on the industry-year median level of managerial incentives and internal supervision, respectively. A firm is assigned to the High_incentive (High_sup) subgroup if the value of *Incentive* (*Sup*) exceeds the industry-year median.

We re-estimate Equation (1) and report the results in Columns (3)–(6) of Table 5. As expected, the coefficients of *digit* are all positive, but significant only in the High_incentive and High_sup subgroups. Hence, the impact of the digital economy is more pronounced in firms when the levels of legitimacy isomorphism, managerial incentive, and internal supervision are expected to be high.

Table 5. Tests for moderating effects.

Variable	High_Tran	Low_Tran	High_incentive	Low_incentive	High_sup	Low_sup
digit	0.317***	−0.004	0.152*	0.228	.190**	.211
	(3.31)	(−0.04)	(1.68)	(1.53)	(2.52)	(1.38)
Constant	64.280***	63.645***	39.485***	91.684***	59.114***	88.187***
	(6.85)	(3.49)	(3.53)	(7.06)	(4.56)	(7.12)
Control	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
N	10,649	3,260	7,113	6,802	7,100	6,816
R-squared	0.401	0.438	0.424	0.423	.432	.427

Note: This table reports the results of the subsample analysis of digital transformation, managerial incentives, and internal supervision. The t-statistics in parentheses are computed based on standard errors clustered at firm level.
***, **, and, * measure statistical significance at the 1%, 5% and, 10% level, respectively.

4.4.2. Tests for the Moderating Roles of External Adaptive Motivation on the Risk Effect of Digital Economy

4.4.2.1. Moderating effect of media coverage. Media coverage not only guides social topics and the direction of public opinion, but also forms reputation pressure on news parties. Literature typically regards media attention as an external supervision mechanism that can improve corporate governance and operating capacity. Media attention to the isomorphism of digital transformation often focuses the capital market on the degree of corporate digitization. Enterprises with a higher degree of digital transformation tend to form a stronger adaptive incentive structure in the digital economy, which may make it easier for them to obtain more funds with lower financing costs, thereby reducing bankruptcy risk. Referring to Huang and Zhang (2022), media coverage (*Media*) is defined as the natural logarithm of one plus the total number of online news items about a firm in a given year. All firms are sorted in our sample into two groups with respect to media coverage. A firm is assigned to the High_media (Low_media) subgroup if the value of *Media* is higher (lower) than that of the industry-year *Media*. We re-estimate Equation (2) and report the results in Columns (1) and (2) of Table 6, respectively. The coefficient of *digit* is positive and significant in the High_media group but insignificant in the Low_media group. The evidence proves that media coverage has a positive impact on the risk effect of the digital economy.

4.4.2.2. Moderating effect of urban wealth. Regional policy inconsistencies and market segmentation may lead to a gap in the isomorphism of digital transformation and enterprise risk management. Regional policy inconsistencies and market segmentation form urban factor endowment conditions and comparative advantages, which are ultimately reflected in differences in urban wealth. Differences in urban wealth can screen for the formation of a digital economy and corporate bankruptcy risk. Referring to Liu, Cui, and Luo (2022),to examine the moderating role of urban wealth, the entire sample was divided into a higher urban wealth subsample (High_wealth) and lower urban wealth subsample (Low_wealth) based on the median value of the financial revenue of each province. We re-estimate Equation (2) using a subsample analysis and present our results in Columns (3) and (4) of Table 6. As expected, the coefficients of *digit* are significantly positive only in the Low_wealth subgroup. There is a scarcity of digital facilities and weaker enterprise information efficiency in areas with lower urban wealth than in those with higher urban wealth. Therefore, the effect of risk on the digital economy may be more significant in areas with lower urban wealth.

4.4.2.3. Moderating effect of industry competition. Firms may face greater pressure to survive in more competitive industries. Digital transformation helps enterprises gain a competitive advantage in industrial competition and economic benefits to cope with bankruptcy risk. Industry competition affects the isomorphism of digital transformation, especially mimetic isomorphism, which influences

Table 6. Additional analyses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High_media	Low_media	High_wealth	Low_wealth	High_HHI	Low_HHI	High_gov	Low_gov
digit	0.274**	0.152	−0.158	0.293***	0.237***	0.213	0.345***	−0.055
	(2.53)	(1.55)	(−0.92)	(2.73)	(3.07)	(1.52)	(3.22)	(−0.43)
Constant	53.339***	101.024***	35.811**	67.786***	52.087***	77.481***	57.781***	60.302***
	(4.65)	(7.87)	(2.06)	(5.81)	(5.61)	(5.20)	(5.49)	(4.45)
Control	YES	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES
Year × Industry	YES	YES	YES	YES	YES	YES	YES	YES
Observations	7,129	6,786	7,241	6,668	7,338	6,663	7,431	6,481
R-squared	0.422	0.437	0.402	0.427	0.405	0.388	0.415	0.413

Note: This table reports the results of the subsample analysis with respect to media coverage, urban wealth, industry competition, and government governance. The t-statistics in parentheses are computed based on standard errors clustered at firm level.
***, **, and, * measure statistical significance at the 1%, 5% and, 10% level, respectively.

firms' decision-making and business behavior and eventually, their ability to manage bankruptcy risk. We employed a subgroup analysis to examine this issue. The sales-based Herfindahl index (*HHI*) measures the degree of industry competition. A higher value of *HHI* denotes a lower degree of industry competition. All firms were sorted into two groups based on *HHI*. We re-estimate Equation (2) for the High_HHI and Low_HHI groups. Columns (5) and (6) of Table 6 show that the coefficients are positive in the two groups, but only statistically significant in the High_HHI group. This evidence is consistent with the view that the risk effect in the digital economy is more pronounced for firms with lower levels of industry competition.

4.4.2.4. Moderating effect of government governance. Good government governance not only provides a level playing field for the existence of enterprises, but also strengthens the effect of government subsidies on the business operation of enterprises and promotes their sustainable development. There are more financial instruments and sound credit systems in areas with better public governance abilities, which increases the probability of creditworthy companies obtaining loans, improves the efficiency of regional resource allocation, and further reduces the likelihood of firms becoming insolvent or even bankrupt. Therefore, this study focuses on whether and how government governance affects the risk of the digital economy. Referring to Helliwell and Huang (2006), we constructed an index for government governance (*gov*) using principal component analysis for three attributes to proxy for the level of governance. The attributes included the logarithm of the number of corruption cases per million people, total fiscal expenditure per regional GDP, and logarithm of the average monetary wage of employees. We split the full sample according to the governance index into a strong_gov and a weak_gov subgroup. Further, we re-estimate Equation (2) using the subsample analysis. As shown in Columns (7) and (8) of Table 6, we observe a significantly positive coefficient for *digit* in the strong_gov subgroup, whereas the coefficient is insignificantly negative in the weak_gov subgroup. Hence, government governance plays a positive role in the risk effect of digital economy.

5. Discussion and Conclusions

Digital economy development gives birth to new market norms and competition rules, which pushes digital transformation and further forms the legitimacy isomorphism effect to decrease corporate bankruptcy risk. By applying multivariate analyses to Chinese firms incorporated from 2011 to 2019, this study investigated whether and how digital economy development affects bankruptcy risk. We found strong evidence that the relationship between digital economy development and bankruptcy risk is negative. This negative relationship is more pronounced in firms where the degree of digital transformation, managerial incentives, and internal supervision is expected to be high. Conversely, a positive moderating effect is more pronounced in firms with greater media coverage, lower urban wealth and industry competition, and better government governance.

Our results offer several important practical implications for how to play the role of digital economy in corporate risk management. First, it is important to vigorously develop the digital economy and promote new industries, new forms of business, and new technologies represented by the digital economy to encourage more effective corporate legitimacy isomorphism and exert its inhibitory effect on the risk of enterprise bankruptcy.

Second, it is necessary to build the enterprise's internal adaptive incentive structure, strengthen digital empowerment, improve the enterprise incentive supervision mechanism, and enhance the ability of enterprises to adapt to the development of the digital economy. In terms of internal supervision, it is crucial to strengthen the board of directors' oversight role under a single-tier system and optimize the supervisory board's system under a two-tier system. When it comes to management incentives, the assessment of technical innovation and the efficacy of investing in new technologies must be combined with the selection, evaluation, reward and punishment, remuneration and equity of directors, supervisors, and executives.

Third, it is necessary to improve the external adaptive incentive structure of enterprises and the external environment for enterprises to adapt to the development of the digital economy.Giving full play to social media's external governance mechanisms, exploring the connections between metropolitan areas of higher and lower income, and directing the flow of resources can all help reduce the danger of company bankruptcy. On the other hand, it is important to remove the institutional constraints that limit the expansion of industry competitiveness, enhance how the digital economy and government governance are thought of as a whole, and encourage the continual strengthening of government governance.

Notes

1. Based on the New Institutionalism of Organizational Sociology, legitimacy is the extent to which organizational actions are accepted and recognized by different stakeholders, as well as the extent to which they are consistent with universal norms, rules, and beliefs.
2. Normative isomorphism refers to following professional standards and practices established by the institutional environment. Mimetic isomorphism refers to imitating or copying their successful counterparts when the organization is not sure what to do. Coercive isomorphism refers to the pressure from the entities.
3. To exert the effect of the new technology system, it is necessary to establish internal and external systems in line with the new rules of competition.
4. Hangzhou city is the birthplace of digital finance in China. The global digital finance center is located in Hangzhou. Therefore, it is reasonable to expect that the closer the geographical distance to Hangzhou is, the higher the level of digital economy development will be.
5. If total frequency is less than or equal to 1, the enterprise will not be regarded as a digitally transformed enterprise. Hence, we only retain the samples with total frequency greater than or equal to 2.
6. The "terrain relief of the region is flatter" denotes that it is beneficial to the construction of information infrastructure such as information transmission and software industry.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Jianmin Liu http://orcid.org/0000-0003-4770-5115
Shichen Wang http://orcid.org/0000-0002-3602-1343

References

Acemoglu, D., and P. Restrepo. 2020. Robots and jobs: Evidence from US labor markets. *Journal of Political Economy* 128 (6):2188–244. doi:10.1086/705716.

Altman, E. I. 2000. *Predicting financial distress of companies: Revisiting the Z-Score and ZETA models*. New York University: Stern School of Business.

Asness, C., A. Frazzini, and L. Pedersen. 2019. Quality minus junk. *Review of Accounting Studies* 24 (1):34–112. doi:10.1007/s11142-018-9470-2.

Balakrishnan, K., M. B. Billings, B. Kelly, and A. Ljungqvist. 2014. Shaping liquidity: On the causal effects of voluntary disclosure. *The Journal of Finance* 69 (5):2237–78. doi:10.1111/jofi.12180.

Branstetter, L. G., and N. Kwon. 2018. South Korea's transition from imitator to innovator: The role of external demand shocks. *Journal of the Japanese and International Economies* 49:28–42. doi:10.1016/j.jjie.2018.01.004.

Broekhuizen Thijs, L. J., and T. Zhu. 2021. Market orientation and innovation behavior: How do service employees benefit from their uniplex and multiplex intrafirm network centrality? *Industry and Innovation* 28 (10):1270–97. doi:10.1080/13662716.2021.1941800.

Bukht, R., and R. Heeks. 2018. Defining, conceptualizing, and measuring the digital economy. *Development Informatics*, Working Paper.

Chen, C., Y. He, K. Wang, and S. Yan. 2022. The impact of early-life natural disaster experiences on the corporate innovation by CEOs. *Emerging Markets Finance and Trade* 58 (14):3953–75. doi:10.1080/1540496X.2022.2073817.

Cho, E., C. Okafor, N. Ujah, and L. Zhang. 2021. Executives' gender-diversity, education, and firm's bankruptcy risk: Evidence from China. *Journal of Behavioral and Experimental Finance* 30 (2):100500. doi:10.1016/j.jbef.2021.100500.
Dana, J. D., Jr., and E. Orlov. 2014. Internet penetration and capacity utilization in the US airline industry. *American Economic Journal-Microeconomics* 6 (4):106–37. doi:10.1257/mic.6.4.106.
Dhawan, A., L. Ma, and M. H. Kim. 2020. Effect of corporate tax avoidance activities on firm bankruptcy risk. *Journal of Contemporary Accounting & Economics* 16 (2):100187. doi:10.1016/j.jcae.2020.100187.
Goldfarb, A., and C. Tucker. 2019. Digital economics. *Journal of Economic Literature* 57 (1):3–43. doi:10.1257/jel.20171452.
Helliwell, J. F., and H. Huang. 2006. How's your government? International evidence linking good government and well-being. *Social Science Electronic Publishing*, Working Paper.
Hinings, B., T. Gegenhuber, and R. Greenwood. 2018. Digital innovation and transformation: An institutional perspective. *Information and Organization* 28 (1):52–61.3. doi:10.1016/j.infoandorg.2018.02.004.
Huang, T., and X. Y. Zhang. 2022. Media coverage of industry and the cross-section of stock returns. *Accounting and Finance* 62 (S1):1107–41. doi:10.1111/acfi.12819.
Khurana, A. 1999. Managing complex production processes. *Sloan Management Review* 40 (2):85–97.
Lin, C. H., and J. W. Wang. 2017. Distortion of price discount perceptions through the left-digit effect. *Marketing Letters* 28 (1):99–112. doi:10.1007/s11002-015-9387-5.
Liu, D., S. Chen, and T. Chou. 2011. Resource fit in digital transformation. *Management Decision* 49 (10):1728–42. doi:10.1108/00251741111183852.
Liu, Q. Z., B. Cui, and C. Luo. 2022. A study on the fiscal sustainability of China's provinces. *Sustainability* 14 (23):17. doi:10.3390/su142315678.
Nunn, N., and N. Qian. 2014. US food aid and civil conflict. *American Economic Review* 104 (6):1630–66. doi:10.1257/aer.104.6.1630.
Ohlson, J. A. 1980. Financial ratios and the probabilistic prediction of bankruptcy. *Journal of Accounting Research* 18 (1):109–31. doi:10.2307/2490395.
Segal, G., I. Shaliastovich, and A. Yaron. 2015. Good and bad uncertainty: Macroeconomic and financial market implications. *Journal of Financial Economics* 117:369–97. doi:10.1016/j.jfineco.2015.05.004.
Svahn, F., L. Mathiassen, and R. Lindgren. 2017. Embracing digital innovation in incumbent firms: How Volvo cars managed competing concerns. *MIS Quarterly* 41 (1):239–53. doi:10.25300/MISQ/2017/41.1.12.
Tu, W., and J. He. 2023. Can digital transformation facilitate firms' M&A: Empirical discovery based on machine learning. *Emerging Markets Finance and Trade* 59 (1):113–28. doi:10.1080/1540496X.2022.2093105.
Tussyadiah, I. P., and J. Pesonen. 2016. Impacts of peer-to-peer accommodation use on travel patterns. *Journal of Travel Research* 55 (8):1022–40. doi:10.1177/0047287515608505.
Wu, Y., and S. Wu. 2010. Executive compensation: Incentives or self-interests? Evidence from listed firms in China. *Accounting Research* 11:40.
Zervas, G., D. Proserpio, and J. W. Byers. 2017. The rise of the sharing economy: Estimating the impact of Airbnb on the hotel industry. *Journal of Marketing Research* 54 (5):687–705. doi:10.1509/jmr.15.0204.

Appendix

Variable definitions.

Dependent variable	
Z_score	Altman's (2000) Z_scores are calculated using: *Z_score = 6.56 X1 + 3.26X2 + 6.72X3 + 1.05X4 + 3.25*
Independent variable	
digit	Digital economy index using principal component analysis for three primary indicators and 13 secondary indicators.
Control variables	
Size	The natural logarithm of total assets.
ROA	The net income scaled by the book value of total assets.
Equityratio	The total liability divided by owners' equity.
Growth	Growth ratio of sales.
ATO	The ratio of sales to the average value of total assets.
Cashflow	The ratio of operating cash flow to total assets.
INV	The ratio of net inventory to total assets.
SOE	A dummy variable that equals one if the firm is state owned and zero otherwise. A firm is defined as state owned if its ultimate controlling shareholder is the government or a quasi-state institution.
ListAge	The natural logarithm of the sum of the age of the firm plus one.
lnGDP	The natural logarithm of economic development level of each region.
lnGBE	The natural logarithm of general budget expenditure of the province in China.
Moderating variables	
Transformation	The logarithm of occurrence frequency of the keywords related to enterprise digitization in the "management discussion and analysis" sections in the annual report.
Incentive	The logarithm of the total compensation of the sum of the top three salary of directors, supervisors, and executives.
Sup	The principal component analysis technique for four unique attributes, to proxy for the level of internal supervision.
Media	The natural logarithm of one plus the total number of online news items about a firm in a given year.
Urban wealth	Fiscal revenue of each province.
HHI	Sales-based Herfindahl index.
gov	Governance index using the principal component analysis for three attributes.