# Digital-Real integration and enterprise resilience

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**Abstract**

This study empirically investigates the impact and mechanisms of digital-real integration on corporate resilience using data from A-share listed companies between 2013 and 2022. The research findings demonstrate that digital-real integration enhances corporate resilience, a conclusion supported by rigorous robustness tests. Mechanism analysis reveals two primary pathways: First, it alleviates financing constraints to strengthen organizational resilience; second, it boosts innovation capabilities to improve corporate resilience.

**Keywords:** Enterprise resilience; Digital-real integration; Financing constraints; Innovation ability.

## 1. Introduction

Amid profound adjustments in global economic governance and deepening international economic transformation, traditional external shocks such as trade frictions, sudden public health emergencies, and evolving industrial and supply chains have intensified. These challenges create multiple uncertainties for corporate survival and development, directly causing instability in logistics networks, rising production costs, and tighter financing constraints. The resilience demonstrated by enterprises in navigating uncertainty has become a key to breaking through these challenges, drawing widespread attention from academia and industry regarding corporate revitalization strategies. Therefore, under crisis scenarios, how to enhance corporate resilience amidst various emerging uncertainties has emerged as a critical issue requiring urgent attention.

The report of the 20th National Congress of the Communist Party of China proposed "accelerating the development of the digital economy and promoting its deep integration with the real economy." Since the 18th National Congress, the CPC Central Committee has prioritized digital economic development, actively advancing both digital industrialization and industrial digitization. This strategic guidance drives the deep integration of digital and real economies to foster high-quality economic growth. The synergy between digital and real economies enhances corporate resilience by requiring mutual integration of digital and real technologies. Such technological convergence creates new pathways for integrated digital-real economic development. In this process, digital innovation and application innovation leverage real technologies' diversity and rich application scenarios to accelerate the integration of digital solutions across diverse applications. By transforming scientific achievements into practical productivity, emerging technologies enable enterprises to explore new frontiers and business models, providing fresh momentum for sustainable growth. Meanwhile, real technology innovation and enterprise digital transformation harness the amplifying effects of digital technologies to drive intelligent upgrades in R&D, production, and distribution. These advancements reduce costs, improve efficiency, and increase profitability while elevating foundational capabilities. Ultimately, they generate innovative technologies, business formats, and operational models that bolster corporate resilience.

Enterprise resilience is widely recognized as the comprehensive capability of an organization to recover from uncertain shocks, even rebound and undergo iterative renewal. Existing literature primarily explores factors influencing enterprise resilience through micro and macro perspectives. Micro-level internal factors mainly include managerial characteristics and cognitive attributes, while this study focuses on digital-real integration as a macro external factor. Macro-level research on resilience factors primarily emphasizes two aspects: First, government factors play a significant role (Chen Hongchuan, 2021), with studies showing that government support influences enterprise resilience through incentives and constraints. Second, market environment factors (Sheng Yanchao et al., 2024) indicate that the digital economy enhances corporate resilience levels. Despite digital-real integration and enterprise resilience becoming research hotspots, current literature still faces limitations: On one hand, systematic research frameworks have yet to be established regarding the direct effects of digital-real integration on enterprise resilience. On the other hand, the underlying channels and mechanisms through which such empowerment occurs remain unexplored.

Building on this foundation, this study investigates the impact and mechanisms of digital-real integration on corporate resilience using data from A-share listed companies between 2013 and 2022. The findings demonstrate that digital-real integration enhances corporate resilience, with robustness tests confirming the robustness of this conclusion. Mechanism analysis reveals two primary pathways: First, digital-real integration alleviates financing constraints to strengthen corporate resilience; second, it boosts innovation and R&D capabilities, thereby further enhancing organizational resilience.

## 2. Theoretical analysis and research hypothesis

### 2.1 Definition of enterprise resilience

The concept of resilience originated in physics, describing an object's ability to recover and rebound after deformation caused by external forces like impacts or disturbances. From a static perspective, corporate resilience refers to the ideal trait of maintaining organizational stability during major disruptions (Kitano, 2004). In dynamic terms, it encompasses both pre-crisis capabilities for identifying, mitigating, and preventing conflict escalation, and post-crisis adaptive recovery mechanisms that span the entire "pre-disruption-during disruption-post-disruption" cycle (Bahrami & Evans, 2011). From a capability standpoint, corporate resilience represents an organization's survival capacity to rapidly recover and sustain growth when facing destructive events (Allenby & Fink, 2005).

Based on the aforementioned perspective, corporate resilience is a situational concept derived from adversity, representing an enterprise's ability to rapidly adapt, recover, and sustain development in response to external shocks and sustained pressures. Corporate resilience encompasses not only passive crisis-handling capabilities but also proactive opportunities-to-act capacities, thus comprising both resistance and recovery capabilities. Resistance capability refers to an organization's capacity to maintain core business stability with sufficient resources during risks, while recovery capability denotes its ability to swiftly adapt to changes and restore normal performance levels after impacts (Liang Xiaocheng et al., 2024). The synergy between these two forms constitutes a complete closed-loop of corporate resilience: resistance capability acts as a "buffer" for crisis management, while recovery capability injects "propelling force" into organizational rebirth, jointly supporting enterprises' sustainable survival and growth in uncertain environments. Although corporate resilience under external shocks has gained increasing attention, growing scholars emphasize long-term-oriented resilience from broader perspectives. This implies that crises and challenges faced by enterprises encompass not only sudden external environmental turbulence but also minor accumulations, long-term latent risks, and easily overlooked unexpected events in daily operations. Enterprises require continuous self-renewal to achieve resilient development (Chen Junhua et al., 2023).

### 2.2 Definition of digital-real integration

In the digital economy era, the integration of digital and real technologies drives technological application, industrialization, and digital transformation of real industries, providing a technical foundation for enterprises 'resilient development. Digital-real integration represents a dynamic process where digital and real economies deeply intertwine and synergize. At its core, this process uses digital technology as a bridge to facilitate deep integration between digital elements and real economy's production factors, workflows, and business models, achieving optimized resource allocation, enhanced productivity, and innovative value creation. This concept transcends simple "digital technology application in the real economy," emphasizing bidirectional penetration and restructuring at the levels of elements, industries, and ecosystems, forming a symbiotic relationship where "digital empowers the real, while the real nourishes the digital." The integration of digital and real economies exhibits dual characteristics: on one hand, it manifests through the development of digital real economy itself (digital industrialization); on the other hand, it involves empowering and transforming traditional real economy through digitalization (Chen Yulu, 2023).

The Fourth Plenary Session of the 19th CPC Central Committee in 2019 first explicitly recognized data as a production factor. President Xi Jinping emphasized: "We must build a digital economy where data serves as the key element" (Yang Daoling et al., 2022). As a new production factor, data permeates all stages of real economy operations - research and developing, production distribution, and consumption - through collection, analysis, and modeling, fundamentally reshaping resource allocation. This integration breaks traditional spatiotemporal constraints, making data the core engine driving industrial upgrading. From an industrial convergence perspective, digital-real integration manifests through cross-sector collaboration and business model innovation between digital and real industries. On one hand, digital technologies are penetrating all sectors of the real economy, driving digital transformation in traditional industries and giving rise to new business formats like smart manufacturing, intelligent retail, and online education. Conversely, real-world demands are propelling technological iterations, steering digital industries toward more context-sensitive applications. This two-way interaction blurs the boundaries between digital and real industries, creating a dual-track integration path where "digital technology industrialization" and "industrial digitalization" progress in tandem. To deepen digital-real integration, we must organically combine domestic demand expansion strategies with supply-side reforms, leveraging dual drivers from both ends to overcome challenges of "inability to integrate" and "incomplete integration" (Chen Kaixuan & Zhang Shushan, 2024). Since the 18th CPC National Congress, President Xi has repeatedly stressed "strengthening and expanding the digital economy," particularly emphasizing its deep integration with the real economy. At its core, the integration of digital and real economies aims to address efficiency bottlenecks and innovation gaps in the real sector while creating expansive application scenarios and foundational support for the digital economy. Unlike "digital transformation" that focuses on technological upgrades in real industries, economy. Unlike "digital transformation" that focuses on technological upgrades in real industries, this convergence emphasizes a two-way synergy-- where digital technologies are implemented through real-world applications, while real industries gain new vitality through digital innovation.

### 2.3 Enterprise Resilience and digital-real integration

The integration of digital and real economies significantly enhances corporate resilience. The deep integration of the digital economy with the real economy, through leveraging digital technologies to improve resource allocation efficiency and reduce transaction costs, strengthens enterprises' ability to withstand external shocks and recover from setbacks (Luo Liangwen et al., 2024). On one hand, during crisis phases, digital platforms in the real sector enable businesses to rapidly connect information and personnel, swiftly activating their crisis response capabilities. On the other hand, these platforms unite multiple entities in collaborative risk management, reshaping mutually beneficial relationships and building collective resilience. Based on this framework, this paper proposes the following hypothesis:

H1: Digital -real integration improves enterprise resilience.

#### 2.3.1 Financing Constraints and Enterprise Resilience

Under traditional financing models, many enterprises struggle to secure sufficient external funding due to information asymmetry and risk identification challenges, often facing tight capital chains and bank reluctance to lend. Traditional financial institutions, adhering to profit-driven principles and risk control measures, maintain cautious attitudes toward corporate credit operations. This makes it particularly difficult for SMEs to obtain adequate external financing, leading to persistent financing constraints (Tang Song et al., 2020). A World Bank report indicates that 75% of non-financial listed companies in China cite financing constraints as their primary development obstacle, the highest proportion among 80 surveyed countries. The "Questionnaire Tracking Survey Report on Chinese Enterprise Managers" released by the Development Research Center of the State Council also reveals that Chinese enterprises generally consider financing constraints as their main developmental bottleneck (Deng Kebin & Zeng Haijian, 2014).

The integration of digital and real economies offers innovative solutions to alleviate corporate financing constraints and enhance organizational resilience. On one hand, the deep application of digital technologies in the real sector significantly reduces information asymmetry. By establishing dynamic data systems, banks can monitor business operations, improve capital adequacy for credit risk assessment, and mitigate moral hazards and adverse selection risks. On the other hand, this integration enables digital platforms to be deeply embedded in real sectors, allowing enterprises to access more flexible financing through digital credit evaluation systems. During the COVID-19 pandemic, many companies viewed digitalization as a "lifeline" to survive operational crises. The efficiency gains, social collaboration, and optimized resource allocation from digital transformation accelerated recovery and rebound from adverse events (Wang Qin, 2020). Through breaking down information barriers, expanding financing scenarios, and refining credit evaluations, digital-real integration provides "digital empowerment" solutions that directly alleviate financing constraints. This convergence has spawned new financing models like supply chain finance, digital bills, and equity crowdfunding, broadening corporate funding channels. Within industrial internet ecosystems, core enterprises' digital platforms integrate transaction data from upstream and downstream partners, offering SMEs order-based supply chain financing services. This approach reduces capital occupation costs for trading firms, breaks traditional financial institution monopolies, and provides diversified financing options for businesses.

With eased financing constraints, enterprises can bolster resource reserves by expanding cash holdings, building diversified supply chains, and investing in safety infrastructure to enhance their "buffer capacity" for unexpected crises. Manufacturing companies that secure sufficient funds through digital financing can establish raw material safety stockpiles and backup production lines to maintain core operations during supply chain disruptions. Meanwhile, ample capital enables businesses to purchase risk hedging tools like property insurance and credit insurance, reducing direct losses from crises. The alleviation of financing constraints allows companies to allocate more resources to technological R&D and business model innovation, fundamentally boosting their adaptive capabilities to environmental changes. In other words, the integration of digital and real economies enhances corporate resilience by lowering financing costs and diversifying funding channels.

Therefore, the following hypothesis is proposed:

H2: digital-real integration improves enterprise resilience by alleviating financing constraints.

2.3.2 nnovation ability and enterprise resilience

Innovation is the first driving force for development and an important way for enterprises to gain competitive advantages. Research has found that there is a significant correlation between innovation and competitive advantage (Alghanmi, 2020), and innovation has a significant positive impact on competitive advantage (Chatzoglou & Chatzoudes, 2018).

Digital-real integration empowers enterprises with technological tools, data support, and innovative models to break through the time-space constraints and efficiency bottlenecks of traditional R&D. Digitalization eliminates communication barriers between companies, enhances information exchange and knowledge sharing, facilitates internal updates and improvements, while enabling the mining and integration of external information (Zhang Jichang & Longjing, 2022). From the perspective of innovation systems theory, the deep integration of digital technologies into the real economy can optimize the allocation of innovation elements, promote the development, improvement, and diffusion of new technologies, thereby enhancing corporate R&D capabilities. The convergence of digital and real economies has improved the application level of new technologies such as urban IoT, big data, and cloud computing. This accelerates the digitalization and informatization processes of traditional enterprises, enabling them to explore internet-based innovation possibilities through digital elements and technologies beyond conventional technological innovation pathways (An Tongliang et al., 2023). Moreover, the integration of the digital economy with the real economy—particularly in manufacturing—helps reduce information barriers between governments, enterprises, and among businesses (Yang Hutao & Hu Leming, 2023). Enhanced market intelligence facilitates more diversified innovation attempts and development strategies (Si Dengkui et al., 2022). Enterprises integrating digital and real economies demonstrate strong growth potential and significant room for advancement. Their promising prospects attract high-end technical talents, inject fresh vitality into R&D innovation, and enhance overall innovation capabilities. This integration also boosts urban innovation efficiency. The use of digital technologies like the internet facilitates knowledge and information exchange between enterprises, strengthens connections between R&D and production departments, and makes innovation activities more targeted. Simultaneously, it accelerates the absorption and transformation of innovative knowledge by entities, stimulates and reinforces spillover effects from original innovations, thereby improving corporate innovation efficiency.

The transformation of innovative achievements enables enterprises to effectively respond to unexpected crises, mitigate operational risks, and enhance organizational resilience. On one hand, it helps establish technological barriers and strengthen risk resistance capabilities. Companies with proprietary technologies can reduce dependence on external resources through exclusive innovations or counter cost pressures via higher product value-added. This creates a technological generation gap when competitors catch up, maintaining market competitiveness and boosting crisis resilience. On the other hand, it enhances adaptability and accelerates recovery from crises. When facing supply chain disruptions or policy adjustments, the technical flexibility enabled by innovation allows businesses to swiftly transition business models, forming a virtuous cycle of "technology reserves → practical application → renewed innovation." This enables rapid adaptation to industry trends and elevates corporate resilience. Guetal (2021) empirically demonstrated that IT exploratory innovation significantly positively impacts business resilience during operational disruptions. Carugati et al. (2020) further suggested that IT technologies play a crucial role in crisis recovery, helping enterprises transition from normalizing operations to institutionalizing crisis management practices. By breaking path dependence and exploring new approaches, these technologies drive strategic renewal and resilience development (Jiang Luan et al., 2022). The digital-real integration of enterprises, driven by technological convergence as the primary innovation driver, fosters a favorable innovation ecosystem that accelerates technological breakthroughs and ultimately enhances organizational resilience. Therefore, this paper proposes the following hypothesis:

H3: Digital-real integration improves enterprise resilience by improving innovation and R&D capabilities.

## 3. Research design

### 3.1 Data sources

This study selects all A-share listed companies from 2013 to 2022 as research samples. Corporate data primarily comes from the CSMAR database, while macro-level data is sourced from the China Statistical Yearbook. Data screening follows these principles: excluding observation values with ST status; excluding financial industry enterprises; and excluding observations with missing key variables. To avoid interference from outliers and abnormal values, the variables are truncated at the 1st and 99th percentile.

### 3.2 Variable description

3.2.1 The dependent variable

The dependent variable is enterprise resilience (Score). The measurement methods of enterprise resilience mainly include single index method and index system method.Among them, the single index method mainly selects stock return volatility (Meng Qiankun et al., 2025), stock price volatility (Wang Na et al., 2024) and cumulative growth of sales revenue (Chen Junhua et al., 2023) to measure the resilience level of enterprises.In order to comprehensively evaluate enterprise resilience, this paper refers to the research ideas of Zhang Hongchang & Ding Rui (2024), Yang Yang & Lin Zibo (2024), Shi Yiming (2025), and selects 8 secondary indicators from three dimensions of defense ability, recovery ability and growth ability to measure enterprise resilience.Combined with Table 1, the weight of each index is calculated by using the entropy weighting method, and finally the comprehensive score is obtained, that is, enterprise resilience.

Table 1 Enterprise resilience index system

| One-level metric | Secondary indicators | Indicator description |
|---|---|---|
| Defense ability | Return on equity | Net profit/shareholders' equity average balance (%) |
| | Cash holdings level | Total cash held by the enterprise (yuan) |
| | Current ratio | Current assets/current liabilities |
| Recover ability | Total asset growth rate | Total asset increase this year/total asset last year (%) |
| | Operating profit growth rate | This year's operating profit increase/total operating profit of last year (%) |
| Grow up ability | Increase rate of business revenue | Operating income increase of this year/total operating income of last year (%) |
| | Profit per employee | Net profit/person (yuan/person) |
| | Number of people with a bachelor's degree or above proportion | Number of people with a bachelor's degree or above/total number (%) |

3.2.2 Interpretation of variables

The explanatory variable is the level of digital and real integration (DR).According to the existing research, the level of digital integration can be measured mainly by patent citation information (Xu Yan et al., 2024), input-output thought (Xu Yingzhi & Sun Jian, 2009), and coupling evaluation model.If the digital-real ecosystem is regarded as the main system, then the digital economy and the real economy are two subsystems, which realize the coordinated effect together (Jiang Tianying et al., 2014). Based on this, this paper uses the coupling evaluation model to measure the integration level of digital economy and real economy. To this end, this paper first uses the entropy weighting method to calculate the development level of digital economy (DL) and the development level of real economy (RL).Next, referring to the views of Shi Dan & Sun Guanglin (2023) and Liu Yongwen & Li Rui (2024), we select the indicators to measure the development level of digital economy and real economy respectively as shown in Table 2.

Table 2 Index system of digital economy development level & real economy development level

| First-level indicators | Secondary indicators | Third-level indicators |
|---|---|---|
| DL | Digital infrastructure | Optical cable line length (km) -<br>Capacity of mobile telephone switchboards (10,000)<br>Internet broadband access port (10,000)<br>Telephone penetration includes mobile phones (phones/person) |
| | Digital products | Total telecom business (100 million yuan)<br>Revenue from information technology consulting services (ten thousand yuan) |

| | | |
|---|---|---|
| | | Software business revenue (ten thousand yuan) |
| | Digital finance | Digital Financial Inclusion Index |
| | Data elements | There is a proportion(%) of e-commerce transactions<br>Number of websites owned by the enterprise (number) |
| | Agriculture | Value added of agriculture, forestry, animal husbandry and fishery (100 million yuan)<br>Total output value of agriculture, forestry, animal husbandry and fishery (100 million yuan) |
| | Industry | Industrial added value (100 million yuan)<br>Number of industrial enterprises above designated size (units)<br>Total assets of industrial enterprises above designated size (100 million yuan)<br>Main business income of industrial enterprises above designated size (in billion yuan) |
| RL | Construction business | Value added of construction industry (100 million yuan)<br>Number of construction enterprises (units)<br>Total output value of construction industry (ten thousand yuan) |
| | Transport, post and telecommunications | Value added of transportation, storage and postal services (100 million yuan)<br>Highway mileage (km)<br>Number of employed persons in urban towns (10,000) |
| | Wholesale and retail | Value added of wholesale and retail industry (100 million yuan)<br>Number of legal entities in wholesale industry (units)<br>Total wholesale sales (100 million yuan)<br>Employment in wholesale and retail trade units in urban areas (10,000) |
| | Accommodation and catering | Value added of accommodation and catering industry (100 million yuan)<br>Number of legal entities in accommodation and catering industry (no)<br>Turnover of accommodation enterprises (100 million yuan)<br>Employment in urban units of accommodation and catering industry (10,000) |

Drawing on the coupling model used by Wang Zhigang and Xiang Meng (2024), coupling degree (C) and digital-real fusion level (DR) can be calculated by the following formula.

$$C = \frac{DL \times RL}{(\frac{DL + RL}{2})^2} \tag{1}$$

$$DR = \sqrt{C \times \frac{DL + RL}{2}} \tag{2}$$

3.2.3 Mechanism variables

Solvency and Access to Financing (SA) stands out from other financing constraint indices that incorporate endogenous factors like profit and leverage ratios. By focusing exclusively on a company's age and size, the SA Index demonstrates greater robustness (Ju Xiaosheng et al., 2013), which aligns with exogenous testing requirements in mechanism analysis. A higher absolute value of the SA Index indicates more severe financing constraints faced by the enterprise.

Innovation ability (RD). Referring to the practice of Yu Minggui et al. (2016), this paper takes r&d investment as the measurement index of innovation ability.

3.2.4 Control variables

In terms of the selection of control variables, this paper refers to the research of Zhao Tao et al. (2020) and Jiang Juan et al. (2024), taking enterprise size (Size), asset-liability ratio (Dar) and Tobin's Q value (TobinQ) as control variables at the enterprise level, and urban-rural income gap (Gap) and population density (Density) as control variables at the provincial level.

The main variables are defined as in Table 3.

Table 3 Variable definitions

| Variable classes | Variable name | variable | Variable definition and measurement |
|---|---|---|---|

| | | symbol | |
|---|---|---|---|
| Interpreted variable | Enterprise resilience | Score | Based on the index system, the entropy weighting method is used to calculate |
| Explain variable | Integration of numbers and facts horizontal | DR | Based on the index system, entropy weighting method and coupling evaluation model are used measure and calculate |
| Machine-processed variable | Financing constraints | SA | SA index number |
| | Innovation ability | RD | Corporate R&D investment |
| Control variable | scale | Size | Logarithmized total assets |
| | Asset-liability ratio | Dar | Total liabilities/total assets |
| | Tobin Q value | TobinQ | (Market value of circulating stocks + non-circulating stock market value × net assets per share + book value of liabilities) / total assets |
| | Urban and rural residents income divide | Gap | Urban per capita disposable income/ Per capita disposable income of rural residents |
| | Density of population | Density | End of year permanent resident population/land area |

### 3.3 Model Settings

According to hypothesis H1, the following model is designed:

$$Score_{it} = \alpha_0 + \alpha_1 DR_{ct} + \sum Control_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (3)$$

Among them, Score represents the explained variable enterprise resilience, DR represents the explanatory variable enterprise digital-real integration level, Control represents the control variable, Year and Ind are annual and enterprise fixed effects respectively, ε represents the residual term, i represents the enterprise, t represents the year, and c represents the province.

According to hypotheses H2 and H3, the following model is designed by stepwise testing:

$$MV_{it} = \beta_0 + \beta_1 DR_{ct} + \sum Control_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (4)$$

$$Score_{it} = \gamma_0 + \gamma_1 MV_{it} + \sum Control_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (5)$$

Among them, $MV_{it}$ is the mechanism variable, including financing constraint (SA) and enterprise innovation ability (RD).

## 4. Empirical research

### 4.1 Descriptive analysis

The descriptive statistics of the variables are presented in Table 4. The enterprise resilience (Score) ranges from a minimum of 0.02 to a maximum of 0.56, demonstrating broad coverage and significant variation across samples, which effectively reflects the developmental status of enterprises. With a mean value close to the median and a standard deviation of 0.114, the Score appears to follow a normal distribution. Regarding explanatory variables such as digital-real integration level (DR_index), firm size (Size), debt-to-asset ratio (Dar), Tobin's Q-value (TobinQ), urban-rural income gap (Gap), and population density (Density), all exhibit substantial fluctuations in their maximum and minimum values while maintaining near-median means, indicating that these metrics provide reliable indicators of enterprise characteristics.

Table 4 Descriptive statistics of variables

| VarName | Obs | Mean | SD | Min | Median | Max |
|---|---|---|---|---|---|---|
| Score | 18266 | 0.18 | 0.114 | 0.02 | 0.16 | 0.56 |
| DR_index | 18266 | 0.69 | 0.180 | 0.27 | 0.73 | 0.94 |
| Size | 18266 | 21.84 | 1.005 | 19.97 | 21.72 | 24.97 |
| Dar | 18266 | 0.36 | 0.181 | 0.06 | 0.34 | 0.85 |
| TobinQ | 18266 | 2.17 | 1.282 | 0.92 | 1.76 | 8.47 |
| Gap | 18266 | 2.33 | 0.239 | 1.89 | 2.33 | 3.14 |
| Density | 18266 | 853.54 | 887.060 | 15.88 | 639.22 | 3951.48 |

### 4.2 Benchmarking

Column (1) in Table 5 presents regression results without controlling for control variables, annual variations, or firm characteristics. The coefficient of DR_index is 0.0583, statistically significant at the 1% level. Column (2) shows results with control variables but without annual or firm controls, where DR_index's coefficient reaches 0.0379 at the same significance level. Column (3) demonstrates control for both variables while excluding annual variations, yielding a coefficient of 0.1295 at the 10% level. Column (4) incorporates controls for both variables and annual variations, with DR_index reaching 0.0321 at the 10% significance threshold. These findings confirm Hypothesis H1: The integration of digital and real enterprises significantly enhances organizational resilience.

Table 5 Benchmark regression results

| | （1） | （2） | （3） | （4） |
|---|---|---|---|---|
| | Score | Score | Score | Score |
| DR_index | 0.0583*** | 0.0379*** | 0.1295* | 0.0321* |
| | (7.68) | (6.23) | (1.92) | (1.94) |
| Size | | 0.0092*** | 0.0378*** | 0.0095*** |
| | | (8.68) | (8.38) | (2.91) |
| Dar | | -0.3169*** | -0.2821*** | -0.2562*** |
| | | (-60.58) | (-22.32) | (-62.32) |
| TobinQ | | -0.0016*** | -0.0045*** | -0.0022*** |
| | | (-2.91) | (-5.34) | (-4.04) |
| Density | | 0.0000*** | 0.0001*** | 0.0000 |
| | | (11.65) | (4.34) | (1.66) |
| Gap | | 0.0776*** | 0.2873*** | -0.0428** |
| | | (18.22) | (5.56) | (-2.40) |
| _cons | 0.1421*** | -0.1208*** | -1.3387*** | 0.0909 |
| | (26.07) | (-4.53) | (-5.90) | (0.88) |
| N | 19555 | 19555 | 19555 | 19555 |
| Adj. R2 | | | 0.17 | 0.66 |

Note:*, ** and *** indicate that the results are significant at the level of 10%,5% and 1% respectively; t-values in parentheses are the same below.

### 4.3 Robustness test

This paper uses a variety of methods to test the robustness of regression results.

(1) Replace the measurement method of the dependent variable. The score of enterprise resilience calculated by the coefficient of variation is used as the alternative dependent variable for robustness test, and the regression results support hypothesis H1.

(2) Endogeneity Test. To address omitted variable issues and reduce endogeneity interference, we employ the instrumental variable method for endogeneity testing. Regarding instrument selection, existing research indicates that provinces with higher postal office density typically possess more comprehensive basic communication networks, which facilitates early adoption of modern digital technologies (Huang Qunhui et al., 2019) and accelerates the integration of digital and real economies. Therefore, the number of postal offices in 1984 has been used as an instrumental variable to measure the development of both the digital economy and the real economy.To address issues such as weak correlations and dimensionality mismatch caused by cross-sectional data, this study adopts the approach of Huang Yongchun et al. (2022), Liu Yongwen and Li Rui (2024), and Zhang Hu et al. (2023). Specifically, we use the interaction term between the number of post offices per billion population in each province in 1984 and the internet user count (in billions) from the previous period as instrumental variables (IV).The 1984 postal office count per billion population in each province constitutes historical data, established prior to the emergence of digital-integration concepts and thus treated as an exogenous variable. By applying a one-period lag to internet user counts, we effectively eliminated reverse causality interference while maintaining no direct correlation between this variable and corporate resilience. Consequently, the instrumental variables remain uncorrelated with random errors. As evidenced by Table 6's regression results, the selected instrumental variables demonstrate no weak instrument bias. After addressing potential endogeneity concerns, Hypothesis H1 remains valid.

(3) Removal of outliers. First, the 2020 COVID-19 pandemic year was excluded as it may have affected research outcomes. Second, samples from municipalities directly under the central government were removed to eliminate the influence of

exceptional cases. After removing data from the abnormal year and special cases, the test results further validated the conclusions of the benchmark regression analysis.

(4) Add industry fixed effects. The benchmark regression only uses the fixed effects of enterprises and years, and this paper further adds the fixed effects of industries. The regression results are shown in column (3) of Table 7. The coefficient of DR_index is 0.0963, which is significantly positive at the 1% level. The test results further verify the conclusion of the benchmark regression.

(5) Adjusting the cluster to the industry level. The benchmark regression adjusts the cluster at the provincial level, and the results are shown in column (4) of Table 7. The coefficient of DR_index is 0.1129, which is significantly positive at the 1% level. The test results further verify the conclusion of the benchmark regression.

Table 6 Endogeneity test results

| | (1)<br>Score |
|---|---|
| DR_index | 0.5164*** |
| | (3.22) |
| Size | 0.0076*** |
| | (3.50) |
| Dar | -0.2554*** |
| | (-34.02) |
| TobinQ | -0.0022*** |
| | (-3.65) |
| Gap | -0.0116 |
| | (-0.42) |
| Density | -0.0000 |
| | (-0.58) |
| _cons | -0.2776** |
| | (-2.11) |
| N | 19555 |
| Adj. R2 | |

Table 7 Robustness test

| | (1)<br>Score | (2)<br>Score | (3)<br>Score | (4)<br>Score |
|---|---|---|---|---|
| DR_index | 0.0955** | 0.0910*** | 0.0963*** | 0.1129*** |
| | (2.71) | (3.32) | (2.78) | (3.56) |
| Size | 0.0011 | 0.0016 | 0.0015 | 0.0015 |
| | (1.03) | (1.52) | (1.35) | (0.87) |
| Dar | -0.2949*** | -0.2972*** | -0.3200*** | -0.3078*** |
| | (-32.98) | (-28.68) | (-34.74) | (-13.91) |
| TobinQ | 0.0062*** | 0.0062*** | 0.0055*** | 0.0062*** |
| | (7.81) | (6.09) | (7.88) | (7.58) |
| Gap | 0.0027 | 0.0200 | 0.0288 | 0.0228 |
| | (0.17) | (1.44) | (1.60) | (0.85) |
| Density | 0.0001 | 0.0000 | 0.0001 | 0.0001** |
| | (1.23) | (0.44) | (0.94) | (2.25) |
| _cons | -0.0060 | 0.0294 | -0.0432 | -0.0312 |
| | (-0.06) | (0.44) | (-0.50) | (-0.34) |
| N | 17179 | 16263 | 19555 | 19555 |
| Adj. R2 | 0.60 | 0.59 | 0.65 | 0.60 |

### 4.4 Mechanism Test

Mechanism Test Results: As shown in Table 6, the DR_index coefficient in column (1) is-0.0423, which is significantly negative at the 5% level, indicating that digital-integration significantly alleviates financing constraints and thereby mitigates their adverse impact on corporate resilience—thus supporting Hypothesis H2. The DR_index coefficient in column (3) is 4.0481, which is significantly positive at the 1% level, suggesting that digital-integration enhances corporate R&D investment and consequently amplifies the beneficial effects of R&D investment on corporate resilience, thereby improving organizational resilience—thus supporting Hypothesis H3.

Table 8 Mechanism test results

| | (1) SA | (2) Score | (3) research input | (4) Score |
|---|---|---|---|---|
| DR_index | -0.0423** | | 4.0481*** | |
| | (-2.19) | | (2.77) | |
| Size | 0.0244*** | 0.0132*** | 1.4561*** | 0.0084*** |
| | (6.41) | (4.45) | (11.74) | (2.93) |
| Dar | 0.0278*** | -0.2444*** | -1.6185*** | -0.2636*** |
| | (3.45) | (-49.10) | (-4.40) | (-75.05) |
| TobinQ | -0.0099*** | -0.0003 | 0.1820*** | -0.0032*** |
| | (-6.96) | (-0.81) | (4.22) | (-4.74) |
| Gap | 0.0353* | -0.0251 | -0.1386 | -0.0342 |
| | (1.92) | (-1.68) | (-0.13) | (-1.53) |
| Density | -0.0000 | 0.0000*** | 0.0003 | 0.0000 |
| | (-0.23) | (2.99) | (1.14) | (1.22) |
| SA | | -0.0750*** | | |
| | | (-3.94) | | |
| RD | | | | 0.0007*** |
| | | | | (7.00) |
| _cons | 3.0468*** | 0.2459** | -33.3198*** | 0.1173 |
| | (29.78) | (2.47) | (-9.00) | (1.13) |
| N | 17427 | 17427 | 18242 | 18242 |
| Adj. R2 | 0.86 | 0.67 | 0.10 | 0.68 |

## 5. Research conclusions and policy suggestions

### 5.1 Research conclusions

This study examines the impact and mechanisms of digital-real integration on corporate resilience using data from A-share listed companies between 2013 and 2022. The findings reveal that digital-real integration enhances corporate resilience, with robustness tests confirming the robustness of this conclusion. Mechanism analysis indicates that digital-real integration improves corporate resilience by alleviating financing constraints and enhancing innovation capabilities through enhanced R&D capacity.

### 5.2 Policy recommendations

For enterprises, while the complex and ever-changing digital era presents challenges to their survival and development, it also offers broader opportunities for cultivating organizational resilience. Companies should embrace digital-real integration with an open mindset, proactively embedding digital technologies into R&D, production, and manufacturing processes. This drives digital transformation and addresses the persistent reluctance between the digital economy and real economy to integrate, thereby enhancing organizational resilience. Additionally, businesses can cultivate and recruit specialized talent in digital-real integration, guide educational institutions to adjust their academic programs and talent development systems to meet digital workforce demands, improve job-person fit efficiency, avoid human resource waste, and create a virtuous cycle between digital-real integration and human capital development.

To strengthen the governance of digital ecosystem development, governments should enhance infrastructure integration between the digital and real economies. Enterprises implementing digital-real economy convergence projects should receive tax incentives and fiscal subsidies to reduce operational costs. Furthermore, tailored support policies should be implemented based on enterprise diversity. For companies facing intense market competition, financing constraints, or other competitive disadvantages, governments should actively refine policy frameworks. Establishing specialized financing guarantee funds could provide collateral services for SMEs, thereby reducing lending risks for financial institutions, improving loan accessibility, and offering targeted support to businesses.

**REFERENCES**


[1] Chen Hongchuan, Wei Lulu, Li Yunjian, et al., 2021. How Management Innovation Influences Corporate Competitive Advantage: The Role of Organizational Resilience and Government Support During the COVID-19 Pandemic [J]. Journal of Guangdong University of Finance and Economics, 36(5):90-102.

[2] Sheng Yanchao, Tan Zuosi, Xu Shan, et al. ——Research on the Moderating Effects of Institutional Environment and Equity Concentration on Resilience of Digital Economy and Tourism Enterprises [J]. Journal of Tourism, 2024,39(09):47-61.

[3] Kitano,H. Biological Robustness[J]. Nature Reviews Genetics,2004,5,(11):826 - 837.

[4] Bahrami, H. , and S. Evans. Super-Flexibility for Real-Time Adaptation: Perspectives from Silicon Valley [J].California Management Review,2011,53,(3):21 - 39.

[5] Allenby,B. ,and J. Fink. Toward Inherently Secure and Resilient Societies[J]. Science,2005,309,(5737) :1034 - 1036.

[6] Liang Xiaocheng, Lü Kangyin, Chen Si. How Data Assets Empower Enterprise Resilience: Theoretical Mechanisms and Empirical Tests [J/OL].

[7] Chen Junhua, Hao Shuya, and Yi Cheng. 2023. Digital Transformation, Bankruptcy Risk, and Enterprise Resilience [J]. Economic Management, 45(8):26-44.

[8] Chen Yulu, 2023. Theoretical Exploration on the Integration of Digital Economy and Real Economy [J]. Economic Research, 58(9):22-30.

[9] Yang Daoling, Fu Juan, and Xing Yuguan. "Five Key Challenges to Address in the Integration of Digital Economy and Real Economy During the 14th Five-Year Plan Period" [J]. China Development Observation, 2022, (2):65-69.

[10] Chen Kaixuan and Zhang Shushan, 2024. Information Consumption and Digital-real Integration —— Empirical Evidence from National Information Consumption Pilot Programs [J]. Soft Science, 38(12):55-61.

[11] Luo Liangwen, Zhang Linlin, and Wang Chen. "Digital Transformation and Enterprise Resilience: Evidence from Chinese A-share Listed Companies [J]. Reform, 2024(05):64-79.

[12] Tang Song, Wu Xuchuan, Zhu Jia. Structural Characteristics, Mechanism Identification and Effect Differences under Financial Regulation of Digital Finance and Enterprise Technological Innovation —— [J]. Management World, 2020(5).

[13] Deng Kebin and Zeng Haijian. 2014. Financing Constraints of Chinese Enterprises: Characteristic Phenomena and Causality Test [J]. Economic Research, 49(2):47-60.

[14] Wang Qin: "High Resilience Organizations in the Digital Era: People, Single and One", Tsinghua Management Review, No.6, 2020.

[15] ALGHANMI A O. Innovations as the competitive advantage for small and medium enterprises: the case for the Kingdom of Saudi Arabia［J］. Marketing and Management of Innovations, 2020, 2: 196-205.

[16] CHATZOGLOU P, CHATZOUDES D. The role of innovation in building competitive advantages: an empirical investigation［J］. European Journal of Innovation Management, 2018, 21( 1) : 44-69.

[17] Zhang Jichang and Long Jing. Digital Transformation, Dynamic Capabilities, and Corporate Innovation Performance: Empirical Evidence from High-Tech Listed Companies [J]. Economic and Management, 2022(3).

[18] An Tongliang, Wei Jie and Jiang Ge: "Internet-based Innovation of Chinese Enterprises Based on Complex Network", Social Sciences in China, No.10,2023.

[19] Yang Huta and Hu Leming: Uncertainty, Information Production and Digital Economy Development, China Industrial Economics, No.4, 2023.

[20] Si Dengkui, Li Xiaolin, Kong Dongmin and Jiang Chun: "Uncertainty of Trade Policy, Financial Marketization and Innovative Development of Enterprises: A Discussion on the Synergistic Effect of Financial Marketization", Finance and Trade Economics, No.4, 2022.

[21] Hua Jungen, Liu Chang, Zhu Di. 2022. Digital Transformation, Financing Constraints, and Total Factor Productivity of Enterprises [J]. Southern Finance (7):54-65.

[22] Jiang Luan, Ling Yupeng, Zhang Jichang, et al., 2022. How Digital Transformation Affects Enterprise Resilience? —— From the Perspective of Dual Innovation [J]. Techno-Economy, 41(1):1-11.

[23] Meng Qiankun, Liu Yupeng, Xue Youzhi. The Dual Relationship Between Social Responsibility and Enterprise Resilience under Resource Constraints [J]. Journal of Finance and Economics (Zhejiang University of Finance and Economics), 2025(06):112-124.

[24] Zhang Hongchang, Ding Rui. How Digital Transformation Enhances the Resilience of High-Tech Manufacturing Enterprises—— Based on the Mediating Effect of Dynamic Capabilities [J]. Journal of Guizhou University of Finance and Economics, 2025(04):1-11.

[25] Yang Yang, Lin Zibo. Can ESG Ratings Improve Corporate Resilience—— An Empirical Test Based on Multi-Time Point Difference [J]. Journal of Hunan University (Social Sciences Edition), 2024,38(06):73-83.

〔25〕Shi Yiming. Empowering SMEs with Digital Economy to Enhance Resilience: Impact Effects and Pathways [J]. Statistical Decision, 2025,41(02):179-183.

[26] Xu Yan, Bi Mengxiao, Chai Ying. Research on Digital-Physical Integration's Impact on Innovation Efficiency in Key Core Technology Fields—— A Data-Based Analysis of Chinese A-share Listed Companies [J/OL].

[27] Xu Yingzhi, Sun Jian. Integration of Information Industry and Manufacturing—— A Performance-Based Study [J]. China Industrial Economics, 2009(07):56-66.

[28] Jiang Tianying, Hua Minghao, Xu Qiang, et al. Mechanism and Spatial Differentiation of Regional Innovation and Urbanization Coupling Development—— A Case Study of Zhejiang Province [J]. Economic Geography, 2014, 34(06):25-32.

[29] Shi Dan, Sun Guanglin. The Impact of Digital-Economy-Real-Economy Integration on Green Innovation [J]. Reform, 2023, (02):1-13.

[30] Liu Yongwen, Li Rui. Can Digital-Physical Integration Improve Factor Market Distortions [J]. Soft Science, 2024,38(08):70-77.

[31] Wang Zhigang, Xiang Meng. Path Analysis of Digital-Physical Integration: A Quasi-Natural Experiment Based on Big Data Comprehensive Pilot Zones [J]. Economic Issues Exploration, 2024, (09):95-112.

[32] Ju Xiaosheng, Lu Di, Yu Yihua. Financing Constraints, Working Capital Management and Enterprise Innovation Sustainability [J]. Economic Research, 2013,48(01):4-16.

[33] Yu Minggui, Fan Rui, Zhong Huijie. China's Industrial Policy and Corporate Technological Innovation [J]. China Industrial Economics, 2016, (12):5-22.

[34] Zhao Tao, Zhang Zhi, Liang Shangkun. Digital Economy, Entrepreneurial Activity and High-Quality Development —— Empirical Evidence from Chinese Cities [J]. Management World, 2020,36(10):65-76.

[35] Jiang Juan, Liu Jianjiang, Xu Diaorong. Does Digital-Physical Integration Promote High-Quality Corporate Development [J]. Macroeconomic Research, 2024, (10):72-89.