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Digital Transformation and Innovation Efficiency of "SRDI" SMEs

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Abstract: In the era of digital economy, the implementation of innovation-driven development strategies necessitates the participation of specialized, refined, distinctive, and innovative (SRDI) SMEs. Digital transformation has injected robust momentum into enhancing the innovation efficiency of SRDI enterprises. This study empirically examines the relationship between digital transformation and the innovation efficiency of SRDI SMEs, along with its underlying mechanisms, using a sample of 405 SRDI enterprises listed on China's A-share market from 2010 to 2022 and employing a fixed-effects model. The findings reveal that digital transformation significantly enhances the innovation efficiency of SRDI enterprises. Mechanism analysis confirms that digital transformation achieves this by alleviating financing constraints, and these conclusions remain robust after a series of rigorous tests. Further research demonstrates heterogeneous effects across ownership types and regional distributions: the incentive effect of digital transformation on innovation efficiency is more pronounced in non-state-owned enterprises and those located in central and western regions. These conclusions deepen the understanding of the nexus between corporate digital transformation and innovation efficiency. Accordingly, this study proposes recommendations such as advancing digital strategic transformation, strengthening policy guidance, optimizing financial supply structures, and fostering digital ecosystems, providing empirical insights for enterprises to explore digital innovation pathways.

Keywords: Digital Transformation; Innovation Efficiency; " SRDI" Enterprises; Risk-Taking

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1.Introduction

The report of the 20th National Congress of the Communist Party of China explicitly emphasized "supporting the development of Specialized, Refined, Distinctive, and Innovative (SRDI) enterprises." Under this policy-driven guidance, the cultivation of SRDI enterprises has flourished, becoming an indispensable force in China's high-quality economic development. With the advent of the digital economy era, corporate digital transformation enhances value creation capabilities by reshaping production methods, operational management, and organizational models[1]. The rapid advancement of digital technologies has spearheaded a new wave of technological revolution and accelerated industrial transformation, offering SRDI enterprises opportunities to elevate innovation efficiency and achieve high-quality growth. Thus, focusing on SRDI SMEs as the primary research subjects to conduct an in-depth analysis of the relationship between digital transformation and their innovation efficiency holds significant practical value for unlocking their innovation potential and ensuring the effective implementation of digital strategies.

Recent years have seen abundant research on digital transformation and corporate innovation globally. Existing studies explore their interplay from multiple dimensions, such as digital technology adoption[2] and corporate governance[3]. Technological advancements play a pivotal role in driving innovation through digital transformation. From a factor allocation perspective, digital transformation optimizes the allocation of labor, capital, and knowledge-technology resources, thereby enhancing innovation efficiency[4]. While most scholars agree that digital transformation fosters innovation, some propose a "digital paradox," arguing that excessive digital investments may lead to resource waste and labor mismatches, ultimately hindering innovation performance[5].

Existing research on the empowerment of digital technologies for corporate innovation efficacy has yielded fruitful results, laying a theoretical foundation for this study. However, SRDI enterprises still face internal and external constraints such as R&D funding and market challenges[6]. Financing constraints, in particular, render innovation breakthroughs highly challenging. Current studies have analyzed the impact of knowledge networks on SRDI enterprises' innovation performance[7] and the mediating role of digital finance in alleviating financing constraints[8]. Nevertheless, there remains insufficient exploration of how digital transformation enhances the innovation efficiency of SRDI SMEs, and consensus on its internal mechanisms is yet to be established.

To address this gap, this study investigates the impact of digital transformation on the innovation efficiency of SRDI SMEs, with a focus on the mediating role of financing constraints, aiming to provide theoretical insights for advancing digital transformation among SMEs and fostering the high-quality development of SRDI enterprises.

2.Theoretical Analysis and Research Hypotheses

2.1 Impact of Digital Transformation on Innovation Efficiency of SRDI SMEs

Against the backdrop of deepening digital economic development, digital transformation injects new momentum into enhancing the innovation efficiency of SRDI SMEs through three mechanisms: resource reconfiguration, information synergy, and human capital activation.

First, based on the resource-based theory: Digital technology-driven resource aggregation effects break down traditional factor allocation barriers. By establishing intelligent systems that integrate data flows and resource flows, digital transformation enables precise matching and dynamic scheduling of knowledge, technology, and capital. It enhances the utilization efficiency of innovation resources through optimized allocation[9] , reducing per-unit innovation costs, accelerating core technology R&D iteration, and improving the input-output ratio of R&D investments, thereby forming a "specialization–high added value" innovation cycle.

Second, digital networks reshape information interaction paradigms across the entire value chain. Real-time data platforms eliminate bottlenecks between R&D, production, and market feedback, constructing an agile innovation chain of "demand perception–technology response–product iteration." Data-driven feedback mechanisms not only reduce information transmission variation coefficients but also compel enterprises to pursue exploratory innovation. When dynamic market demands are transmitted instantaneously to R&D teams via digital channels, firms can rapidly validate innovation directions through simulation and digital twin technologies, facilitating efficient transformation of research outcomes and boosting innovation efficiency[10].

Third, human capital serves as the micro-foundation for improving innovation efficiency in SRDI enterprises. However, under traditional management models, R&D personnel often remain bogged down in repetitive tasks, constraining their creative potential. Digital transformation enables R&D teams to focus on high-creativity activities through intelligent management systems, while knowledge graphs and collaboration platforms promote the explicit transfer of tacit expertise, resolving "knowledge silo" dilemmas. Additionally, digital technologies quantify individual innovation contributions, establishing dynamic "capability–reward" incentive mechanisms to further enhance talent-driven innovation efficacy[11]. The synergistic integration of these three mechanisms forms a "digital empowerment–innovation value creation" transmission chain, providing a theoretical framework for digital transformation to enhance SRDI enterprises' innovation efficiency. Based on this, we propose:

H1：Digital transformation positively promotes the innovation efficiency of SRDI SMEs.

2.2 Mediating Role of Financing Constraints

As typical representatives of technology-driven enterprises, SRDI SMEs universally face the dilemma of "difficult and costly financing," rooted in structural contradictions such as low credit ratings, insufficient collateral, and mismatched financial products[12]. In the digital economy era, digital transformation leverages technological advantages to alleviate financing constraints by reducing information asymmetry, enhancing signaling effectiveness, and improving information disclosure, thereby fostering incremental improvements in innovation efficiency.

First, digital transformation reduces information asymmetry and rebuilds trust in capital markets. Information asymmetry theory posits that "data silos" between firms and investors are a core cause of financing constraints. By establishing intelligent information exchange systems that integrate R&D, production, and financial data, digital transformation lowers information collection and verification costs through dynamic, visualized data platforms. IoT and blockchain technologies significantly enhance operational transparency, enabling external investors to accurately assess technological value and risk boundaries, mitigating financing exclusion caused by information distortion, and ensuring stable funding for innovation.

Second, digital transformation strengthens signaling effectiveness, creating market-recognized "value labels." The uncertainty and financial volatility of tech enterprises often trigger market skepticism. Digital transformation sends high-quality signals to capital markets through governance optimization and operational model innovation. These signals serve as "certifications" of innovation potential and risk resilience, attracting investors with aligned risk appetites. Moreover, digital transformation facilitates access to government subsidies and innovation funds through policy "endorsements," forming a virtuous cycle of "financing–innovation–refinancing."

Third, digital transformation improves information disclosure mechanisms, amplifying the "multiplier effect" of credit ratings. Digital platforms standardize the disclosure of R&D progress, intellectual property, and market feedback, meeting regulatory requirements while constructing multidimensional credit evaluation systems. Industrial internet platforms quantify technology conversion efficiency, and supply chain finance systems trace fund utilization, enabling financial institutions to develop customized credit models for SRDI enterprises. Transparent fund flow monitoring ensures precise allocation of innovation resources, avoiding efficiency losses from mismanagement, and ultimately realizing a chain reaction of "financing constraint alleviation–innovation resource expansion–innovation efficiency enhancement." Based on this analysis, we propose:

H2: Financing constraints play a mediating role in the relationship between digital transformation and the innovation efficiency of SRDI SMEs.

2.3 Mediating Role of Risk-Taking Propensity

Digital transformation systematically strengthens corporate risk-taking propensity through three synergistic pathways—dynamic strategic decision-making, intelligent governance structures, and transparent information ecosystems—thereby enhancing innovation efficiency.

First, dynamic strategic decision-making drives high-risk innovation initiatives. Digital technologies endow enterprises with dynamic capabilities to break free from traditional strategic path dependency. By capturing real-time market demand fluctuations and technological trends, firms can swiftly identify breakthrough opportunities, shorten R&D decision cycles, and target high-barrier sectors such as semiconductor equipment and biopharmaceutical core reagents.

Second, intelligent governance structures resolve principal-agent conflicts. The immutable nature of blockchain technology and the automated execution of smart contracts establish end-to-end traceability systems for R&D investments, curbing managerial short-term opportunism. Machine learning models quantify the expected value and risk probabilities of innovation projects, offering objective decision-making references for executives and resolving the inherent mismatch between traditional evaluation mechanisms and innovation cycles[13]。 This governance transformation redistributes risk responsibilities, creating incentive-compatible mechanisms between management and shareholders and converting agency costs into innovation momentum.

Third, transparent information ecosystems institutionalize innovation tolerance. Industrial internet platforms enable R&D process visualization and data sharing, significantly reducing information asymmetry between shareholders and management.

Machine learning-based risk quantification models transform subjective judgments into objective probability distributions, raising tolerance thresholds for innovation failure[14]. Collaborative innovation networks via digital ecosystems disperse risks across multiple entities, reducing decision-making friction and fostering an organizational culture of "tolerating trial-and-error and encouraging exploration," thereby enhancing innovation efficiency.

H3: Risk-taking propensity plays a mediating role in the relationship between digital transformation and the innovation efficiency of SRDI SMEs.

3.Research Design

3.1 Sample Selection and Data Sources

This study selects SRDI SMEs listed on China's A-share market from 2010 to 2022 as the research sample. To mitigate data bias, the following filters are applied: Exclude companies labeled as ST, *ST, or in the financial sector; Exclude firms with missing key empirical data; Exclude companies listed for less than one year or inactive during the sample period; Winsorize all continuous variables at the top and bottom 1% to eliminate outliers. The final sample comprises 7447 firm-year observations from 1,220 SRDI enterprises. Raw data are sourced from the CSMAR database, and Stata 18.0 is used for data processing.

3.2 Variable Definitions

（1）Dependent Variable: Innovation Efficiency（Innov）

Innovation efficiency reflects the optimization of resource allocation. Compared to single metrics, the number of invention patents owned by SRDI enterprises more directly captures their innovation capabilities. Following prior studies, this paper constructs an innovation efficiency indicator using the ratio of annual invention patent applications to R&D expenditure:

$$Innov_{i,t} = Patent_{i,t} / \ln(1 + RD_{i,t}) \quad (1)$$

In Equation（1）, $Innov_{i,t}$ represents Innovation Efficiency， $Patent_{i,t}$ represents the total number of invention patent applications, $RD_{i,t}$ denotes R&D expenditure for firm i in year t. To address skewness, R&D expenditure is logarithmically transformed (after adding 1) before ratio calculation.

（2）Independent Variable: Digital Transformation Index (Dig)

Drawing on the methodology of Yu Miao et al[15], this study adopts the Enterprise Digital Transformation Index (Dig) jointly released by the CSMAR database and East China Normal University in 2022. This index comprehensively evaluates six dimensions: strategic leadership, technology-driven practices, organizational empowerment, meso-environmental factors, digital outcomes, and application depth, providing a robust measure of corporate digital transformation.

（3）Mediating Variable: Financing Constraints (SA Index)

The SA Index, widely recognized for its exogeneity in assessing financing constraints, is selected as the proxy for financing constraints following Ju Xiaosheng et al[16]. The formula is: SA Index = -0.727 × Size + 0.043 × $Size^2$ - 0.04 × Age, where Size is the natural logarithm of total assets, and Age represent the firm's establishment years. The absolute value of the SA Index is used, with higher values indicating greater financing constraints.

（4）Control Variables

To ensure robustness, this study controls for variables identified in prior literature: Firm size (Size)、Asset-liability ratio (Lev)、Return on assets (ROA)、Proportion of independent directors (Indep)、Duality of roles (Dual)、Board size (Board)、Cash flow ratio、Equity balance (Balance). Fixed effects for individual firms (Stock), years (Year), and industries (Industry) are included to control unobserved heterogeneity. Detailed variable definitions are summarized in Table 1.

Table 1 Variable Definitions

Type	Symbol	Measurement
Dependent Variable	*Innov*	Natural logarithm of (Total invention patent applications / (R&D expenditure + 1))
Independent Variable	*Dig*	Digital Transformation Index from CSMAR Database
Mediating Variable	*SA*	Absolute value of the SA Index
	RiskTap	Frequency of myopic terms in annual MD&A reports

Type	Symbol	Measurement
Control Variables	*Size*	Natural logarithm of total assets
	Lev	Total liabilities divided by total assets
	ROA	Net profit divided by average total assets
	Indep	Number of independent directors divided by total board members
	Dual	Dummy variable: 1 if CEO and board chair roles are separate, 0 otherwise
	Board	Natural logarithm of the number of board members
	Cashflow	Net cash flow from operations divided by total assets
	Balance	Shareholding ratio of the 2nd to 5th largest shareholders relative to the largest shareholder
	Stock	Control for individual firm heterogeneity
	Year	Control for industry heterogeneity
	Industry	Control for time-specific trends

3.3 Model Construction

Building on the hypotheses proposed earlier and existing research, this study constructs the following baseline regression model:

$$Innov_{i,t} = \alpha_0 + \alpha_1 Dig_{i,t} + \sum \alpha_2 Control + \mu_i + \lambda_t + ind_j + \varepsilon_{it} \quad (2)$$

$$Med_{i,t} = b_0 + b_1 Dig_{i,t} + \sum b_2 Control + \mu_i + \lambda_t + ind_j + \varepsilon_{it} \quad (3)$$

$$Innov_{i,t} = \delta_0 + \delta_1 Dig_{i,t} + \delta_2 Med_{i,t} + \sum \delta_3 Control + \mu_i + \lambda_t + ind_j + \varepsilon_{it} \quad (4)$$

Where，I and t denote the firm and year, respectively. Dependent variable: Innov represents innovation efficiency. Independent variable: Dig is the digital transformation index. Mediating variable: Med denotes the mediator(financing constraints or risk-taking propensity)), Control variables: Control includes all specified control. Firm fixed effects、Year fixed effects and Industry fixed effects are introduced into the model(μ_i、λ_t、and ind_j). ε_{it} is random error term。

4.Empirical Results Analysis

4.1 Descriptive Statistics

Descriptive statistics for key variables are presented in Table 2. The mean value of innovation efficiency（Innov）is 0.109, with a standard deviation of 0.078. Some firms reported zero patent applications during the study period, indicating significant dispersion in innovation efficiency across enterprises. The digital transformation index（Digital）has a maximum value of 6.401 and a mean of 1.393, reflecting substantial variation in digital maturity among sample firms. All other variables exhibit reasonable distributions.

Table 1 Descriptive Statistics

Variable	Mean	SD	Min	Max	Med	N
Innov	0.109	0.0780	0	0.641	0.110	8338
Dig	1.393	1.404	0.000	6.301	1.099	8338
SA	-3.761	0.241	-4.890	-3.033	-3.755	8338
RiskTap	0.133	0.148	0.000	5.405	0.096	8338
Size	21.380	0.808	19.160	26.390	21.300	8338
Lev	0.313	0.176	0.011	0.995	0.288	8338
ROE	0.059	0.141	-1.916	1.751	0.069	7447
Indep	38.140	5.536	14.291	75.000	37.500	8322
Dual	0.434	0.496	0.000	1.000	0.000	8338
Board	2.060	0.185	1.386	2.708	2.079	8322
Cashflow	0.042	0.068	-0.528	0.839	0.043	8338
Balance	0.882	0.639	0.014	4.000	0.715	8323

4.2 Baseline Regression Analysis

Table 3 reports the regression results. A stepwise regression approach is employed to analyze the relationship between digital transformation and innovation efficiency. Columns (1) to (4) show that the coefficient of Dig remains significantly positive at the 1% level after controlling for firm, year, industry fixed effects, and other covariates. These results preliminarily validate H1, confirming that digital transformation significantly enhances the innovation efficiency of SRDI SMEs.

Table. 3 Benchmark regression results

Variable	(1)	(2)	(3)	(4)
	Innov	Innov	Innov	Innov
dig	0.002***	0.001***	0.001***	0.001***
	(52.023)	(8.026)	(19.533)	(5.369)
Size			0.021***	0.021***
			(19.830)	(10.977)
Lev			0.002	-0.002
			(0.308)	(-0.344)
ROE			0.030***	-0.000
			(5.073)	(-0.019)
Indep			-0.000***	0.000
			(-2.585)	(1.402)
Dual			0.003**	0.001
			(2.176)	(0.396)
Board			-0.002	0.012*
			(-0.439)	(1.676)
Cashflow			-0.010	0.001
			(-0.819)	(0.053)
Balance2			0.001	-0.004
			(0.843)	(-1.629)
Constant	0.035***	0.066***	-0.367***	-0.410***
	(22.066)	(11.806)	(-14.201)	(-9.189)
Observations	29,750	7,437	6,757	6,588
R-squared	0.083	0.653	0.126	0.667
stock FE	NO	YES	NO	YES
Year FE	NO	YES	NO	YES

Note：* p<0.1，** p<0.05，*** p<0.01，The data in parentheses are t-values.

4.3 Robustness Tests

Variable substitution: To address potential measurement biases, alternative proxies are used. The dependent variable is redefined as the natural logarithm of total granted patents divided by R&D expenditure（Innov_new）; Following Wu Fei et al[17], digital transformation（Dig_new）is measured using keyword frequencies from annual reports, focusing on foundational and applied technology adoption. Regression results in Table 4 (Columns 1–2) remain robust, with coefficients staying positive and significant.

Table 4 Replace the main variables

Variable	(1)	(2)
	Innov_new	Innov
Dig	0.00033**	
	(2.261)	
Dig_new		0.004***
		(4.724)
Constant	-0.257***	-0.399***
	(-6.275)	(-9.621)
Control	YES	YES
Observations	6,365	6,973
R^2	0.635	0.653
Stock/Year/Industry	YES	YES

4.4 Endogeneity Treatment

To mitigate endogeneity, instrumental variable (IV) approaches are adopted. Drawing on Zhang Xuan et al[18], two IVs are used: (1) the average digital transformation index of peer firms in the same city and industry（IV-list）, and (2) the one-period lagged digital transformation index（IV-lag）. The 2SLS results in Table 5 show no weak instrument or over-identification issues (Columns 1 and 3). After addressing endogeneity, the positive effect of digital transformation on innovation efficiency remains significant at the 1% level (Columns 2 and 4), confirming the robustness of baseline findings.

Table 5 IV test results

Variable	IV-lis		IV-lag	
	(1)	(2)	(3)	(4)
	Dig	Innov	Dig	Innov
Dig		0.001**		0.002***
		(2.092)		(3.127)
IV	0.382***		0.345***	
	(22.449)		(22.022)	
Control	YES	YES	YES	YES
Stock/Year/Industry	YES	YES	YES	YES
KP rk LM statistic	452.953		426.656	
KP rk Wald F statistic	503.958		484.956	
	（16.380）		（16.380）	
Observations	6,208	6,208	6,175	6,175
R^2		0.033		0.027

4.5 Mechanism Analysis

Innovation investment is a long-term and continuous process, accompanied by internal and external information asymmetry and unpredictable investment risks, in which financing constraints and corporate risk-taking tendencies hinder the progress

of innovation activities. Therefore, this paper takes financing constraint (SA) and enterprise risk-taking propensity (RiskTap) as mediating variables, and uses a step-by-step test method to verify the internal mechanism of financing constraint (SA) and enterprise risk-taking propensity (RiskTap) on the relationship between digital transformation and innovation efficiency of specialized, special and new SMEs, and the results are shown in Table 6.

Regression results indicate that in Column (2), the coefficient for the digital transformation index is -0.001, significant at the 5% level, demonstrating that digital transformation significantly alleviates financing constraints for SRDI enterprises. In Column (3), the coefficient for digital transformation remains 0.001, while the coefficient for financing constraints（SA） is -0.057, also significant and negative. These results further confirm the existence of a partial mediating effect, implying that SRDI SMEs improve their innovation efficiency by leveraging digital transformation to mitigate financing constraints, thereby validating Hypothesis H2.

Similarly, in Column (4), the coefficient for digital transformation is -0.001, significant and negative, indicating that digital transformation significantly enhances the risk-taking propensity of SRDI enterprises. In Column (5), the coefficient for digital transformation remains 0.001, while the coefficient for risk-taking propensity（RiskTap）is -0.019, significant and negative. This further supports the partial mediating effect, suggesting that SRDI SMEs enhance innovation efficiency by increasing their risk-taking propensity through digital transformation, thereby confirming Hypothesis H3.

Table6 The mechanism test results

Variables	(1)	(2)	(3)	(4)	(5)
	Innov	**SA**	**Innov**	**RiskTap**	**Innov**
SA			-0.057***		
			(-3.051)		
RiskTap					-0.019**
					(-2.098)
Dig	0.001***	-0.001***	0.001***	-0.001**	0.001***
	(5.443)	(-4.589)	(5.246)	(-2.062)	(5.448)
Constant	-0.392***	-2.888***	-0.558***	0.187***	-0.388***
	(-8.695)	(-88.577)	(-7.901)	(2.696)	(-8.593)
Control	YES	YES	YES	YES	YES
Observations	6,444	6,481	6,444	6,455	6,418
R^2	0.668	0.985	0.669	0.671	0.668
Stock/Year/Industry	YES	YES	YES	YES	YES

4.6 Heterogeneity Analysis

The impact of digital transformation on innovation efficiency is often moderated by multiple factors. Enterprises with stronger reliance on digital technologies and more advanced digital infrastructure are better positioned to harness the positive innovation feedback from digital transformation. To explore the heterogeneous effects across different sample groups, this study conducts further analysis based on ownership type and industry attributes.

(1) Ownership Heterogeneity

Ownership type, as a critical classification criterion, influences corporate digital transformation. State-owned enterprises (SOEs) hold advantages in resources, talent, and policy support, enabling them to secure more direct government-backed resources for innovation activities compared to non-SOEs. Consequently, this study divides the sample into SOEs and non-SOEs for subgroup regression. Results in Columns (1) and (2) of Table 7 show that the coefficient for digital is higher and statistically significant at the 1% level for SOEs. This indicates that digital transformation exerts a more pronounced positive effect on innovation efficiency in SOEs relative to non-SOEs.

(2) Industry Heterogeneity

Given variations in technological R&D across industries, SRDI enterprises are categorized into manufacturing and non-manufacturing sectors. Regression results using Model (1) are reported in Columns (3) and (4) of Table 7. The coefficient for digital transformation in manufacturing firms is 0.085, significant at the 1% level, while the coefficient for non-manufacturing firms is 0.092, significant at the 5% level. Inter-group coefficient comparisons reveal that digital transformation drives more substantial improvements in innovation efficiency for manufacturing SRDI enterprises, likely due to their higher dependency on process innovation and technology-intensive operations.

Table7 Heterogeneity test results

Variables	(1)	(2)	(3)	(4)
	Innov	Innov	Innov	Innov
	Non-SOE	SOE	Manufacturing	Non-manufacturing
dig	0.077***	0.111**	0.085***	0.092**
	(4.439)	(2.219)	(4.867)	(2.245)
Constant	-0.397***	-0.574***	-0.394***	-0.446***
	(-7.983)	(-4.079)	(-7.981)	(-3.739)
Control	YES	YES	YES	YES
Observations	5,619	738	5,550	1,033
R-squared	0.670	0.727	0.664	0.700
stock FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

5.Conclusions and Policy Implications

5.1 Conclusions

This study empirically investigates the impact of digital transformation on the innovation efficiency of SRDI SMEs using panel data from A-share listed firms in China (2010–2022), with a focus on the mediating roles of financing constraints and risk-taking propensity. The findings reveal three key insights: Digital transformation significantly enhances the overall innovation efficiency of SRDI SMEs；Financing constraints and risk-taking propensity partially mediate the relationship between digital transformation and innovation efficiency；The innovation-enhancing effects of digital transformation exhibit significant heterogeneity across ownership types and industries, with stronger impacts observed in state-owned enterprises (SOEs) and manufacturing firms.

5.2 Policy Recommendations

Based on these findings, this study proposes the following targeted recommendations:

（1）For SRDI Enterprises: Proactively integrate into the digital era by advancing transformation strategies. Establish efficient information exchange mechanisms and improve disclosure quality to alleviate financing constraints and secure funding foundations. Prioritize operational efficiency gains and innovation activation through digital tools, leveraging cost reduction and value creation to drive high-quality development.

（2）For Policymakers: Design tailored support policies addressing the financing challenges faced by SRDI SMEs during digital transformation. Strengthen fiscal subsidies, tax incentives, and region-specific innovation incentives while enhancing regulatory frameworks to foster a robust digital ecosystem.

（3）Systemic Enhancements: Develop comprehensive SRDI service platforms to streamline information flows and risk management. Strengthen intellectual property protection and institutionalize innovation-tolerant mechanisms (e.g., risk-sharing models, collaborative innovation networks) to amplify the risk-taking capacity of SRDI enterprises. Optimize external environments to maximize the role of digital transformation in boosting risk appetite, thereby accelerating breakthroughs in

core technologies and global value chain upgrading.

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Conflict of Interests

The author(s)declare(s) that there is no conflict of interest regarding the publication of this paper.

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