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Research Paper

The systemic transformation of small and medium enterprises (SMEs) in the era of digitalization: Challenges and strategic pathways in emerging industrial regions of China

Chaoqi Wu * and Arnold Tóth

Budapest University of Economics and Business, Budapest, Hungary

* Correspondence: 1095476761@qq.com

Abstract: This study explores critical factors influencing digital transformation in small and medium-sized enterprises (SMEs), focusing on management support, employee skill development, and technology adoption. Drawing on the Technology-Organization-Environment (TOE) framework and Organizational Learning Theory, three hypotheses were tested using survey data from 303 SMEs across manufacturing, services, retail, and IT sectors in emerging industrial regions of central and western of China. Through correlation analysis and multiple regression analysis, results reveal that (1) digital leadership enhances technology adoption, (2) employee skill development is vital to transformation success, and (3) technology adoption improves financial performance. The study highlights challenges such as uneven digital infrastructure and policy disparities and offers region-specific strategies to address them. These insights serve as a practical roadmap for policymakers and SME leaders, stressing the need to align digital initiatives with local socio-economic conditions. The findings also have global relevance, as SMEs in developing regions like Southeast Asia, Latin America, Eastern Europe, and Africa face similar obstacles including limited infrastructure, skill shortages, uneven policy support, and resource constraints. This makes these findings widely applicable insights for international policymakers and business leaders.

Keywords: Digital transformation, SMEs, management support, employee skill development, technology adoption, TOE framework, organizational learning theory.

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1. Introduction

Small and medium-sized enterprises (SMEs) account for approximately 70% of global employment, which underscores their critical role in economic development and job creation worldwide (International Labour Organization, 2023). Beyond contributing to economic growth, SMEs foster innovation and create new market opportunities. However, the rapid proliferation of digital technologies—such as big data, artificial intelligence, cloud computing, and the Internet of Things (IoT)—has profoundly transformed business operations, reshaped market dynamics and enhanced competitiveness (Schallmo & Williams, 2018). In this evolving landscape, digital transformation has become a critical determinant of SMEs' long-term survival and growth.

Despite the transformative potential of digital technologies, SMEs face unique barriers compared with larger firms, including limited financial resources, inadequate technical expertise, and underdeveloped infrastructure (OECD, 2019a). Yet, digital transformation also presents opportunities for SMEs to overcome these challenges. By leveraging digital innovations, SMEs can improve operational efficiency, enhance customer experiences, and expand into new markets with minimal resources (Vial, 2019). For instance, e-commerce platforms enable SMEs to engage directly with global consumers, extending their market reach. Empirical studies confirm that digitally mature firms achieve higher sales growth, productivity gains, and greater resilience to market disruptions (Verhoef et al., 2021). According to a research report on digital transformation of SMEs from the China Academy of Information and Communications Technology (CAICT) and All Alliance (2023), digitally mature

SMEs in China have demonstrated faster sales growth and higher operational efficiency, which reflects the positive impact of digital adoption on competitiveness.

Importantly, digital transformation involves more than technology adoption: it requires systemic organizational change, including strategic realignment, cultural adaptation, employee upskilling, and leadership development. Success depends on integrating technology with business processes and market strategies (Verhoef et al., 2021). For example, while automated processes may enhance efficiency, they require comprehensive employee training to ensure effective implementation, and managers must cultivate a culture that embraces change and adapts to technological environments (Westerman et al., 2014). A lack of technical expertise and a clear digital vision often hinder progress, which highlights the critical role of digital leadership in aligning technologies with business strategies and mobilizing internal resources (Schallmo & Williams, 2018). The following table (Table 1) provides a summary of the key differences between SMEs and large enterprises in terms of the challenges and opportunities encountered during digital transformation.

Table 1. Comparison of digital transformation barriers and opportunities between SMEs and large enterprises. *Source: adapted from Schallmo & Williams (2018), Kane et al. (2015), OECD (2019a), and CAICT & All Alliance (2023).*

Dimension	SMEs	Large Enterprises
Financial Resources	Limited budgets, difficult to invest in long-term digital initiatives (Li et al., 2018; OECD, 2019a)	Ample funding to support continuous investment in digital solutions (Verhoef et al., 2021)
Technical Expertise	Lack of internal IT staff; difficulty attracting tech talent (Ghobakhloo, 2020; DeStefano et al., 2018)	In-house experts and access to top-tier consultants (Hess et al., 2016)
Infrastructure	Underdeveloped systems, limited access to advanced digital tools (Xu et al., 2018; Vial, 2019)	Mature infrastructure, automated processes (Schallmo & Williams, 2018)
Organizational Agility	More flexible, quicker decision-making (Warner & Wäger, 2019)	More bureaucratic, slower to implement change (Westerman et al., 2014)
Strategic Vision	Often lacks clear digital roadmap (Kane et al., 2015)	Comprehensive strategies guided by long-term goals (Fitzgerald et al., 2013)
Market Reach	Can leverage e-commerce to access new markets (CAICT & All Alliance, 2023)	Already possess established international presence (OECD, 2019b)
External Support Dependence	Relies heavily on government or third-party support (Acs et al., 2017)	Less reliant due to internal capabilities

Given their limited resources, SMEs often depend on external support such as government subsidies, consulting services, and collaborations with technology providers (Acs et al., 2017). These partnerships allow SMEs to access expertise and resources, thereby accelerating their digital transformation journey.

This study identifies the key factors influencing SMEs' digital transformation success and offers practical recommendations for business leaders and policymakers. Specifically, it examines the roles of management support, employee skill development, and technology adoption rates in shaping successful transformation outcomes. Using survey-based analysis of SMEs in emerging industrial regions of China, this paper proposes strategic pathways to achieve digital transformation through resource optimization and external collaborations.

2. Literature Review

2.1. Technology Adoption Theories and Digital Transformation

Two widely used theoretical frameworks in analysing digital transformation are the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DOI) theory. TAM, derived from the Theory of Reasoned Action (TRA), posits that technology adoption is driven by perceived usefulness and ease of use—users are more likely to adopt a technology if they

believe it offers clear benefits and if it is easy to operate (Davis, 1989). While TAM effectively explains individual-level adoption, its direct application to SMEs is limited because organizational adoption also depends on leadership, culture, and resource availability (Venkatesh et al., 2016).

The Unified Theory of Acceptance and Use of Technology (UTAUT) builds on TAM by incorporating social influence and facilitating conditions, thereby offering a broader lens to understand organizational adoption (Venkatesh et al., 2016). Dwivedi et al. (2019) highlight the role of external influences, including organizational settings and social dynamics, which are particularly relevant for SMEs facing resource constraints. Oliveira and Martins (2011) also emphasize the significance of organizational and environmental factors in shaping SMEs' technology decisions. Recent studies further underscore the transformative potential of artificial intelligence (AI) and other advanced technologies for improving operational efficiency and performance (Wamba-Taguimdje et al., 2020).

DOI theory, introduced by Rogers (2003), provides a macro-level view of how innovations diffuse across social systems, from early adopters to laggards. However, its applicability to SMEs is limited due to its lack of focus on organizational dynamics and contextual barriers – such as limited infrastructure and cultural factors – that are critical in SMEs' digital transformation (Ghobakhloo, 2020).

2.2. Unique Challenges for SMEs

SMEs face a range of structural barriers to digital transformation, including financial constraints, skill shortages, and limited infrastructure (OECD, 2019a). While these challenges are well-documented, most studies focus on SMEs in developed economies, with fewer exploring the specific issues faced in developing regions. In emerging markets, uneven access to digital infrastructure and financing options often hinders technology adoption (Ghobakhloo, 2020). Domestic reports also show that Chinese SMEs, particularly those in less-developed regions, face additional barriers such as uneven digital infrastructure and limited access to government support, as highlighted by the Ministry of Industry and Information Technology (2024).

Despite these constraints, SMEs' flexibility and less hierarchical structures enable them to adapt quickly to incremental innovations and customer-driven solutions (Sagala & Őri, 2024). Digital transformation presents opportunities for SMEs to enter niche markets, build leaner operations, and leverage digital platforms – such as social media and e-commerce – for competitive advantage (Nazaruddin & Utami, 2024). However, digital maturity levels vary significantly across SMEs, and adoption patterns are highly influenced by managerial digital competencies and overall organizational readiness (Romero & Mammadov, 2024).

Entrepreneurial and digital leadership are crucial for overcoming these barriers. Li et al. (2018) show that leaders with a strong digital vision foster organizational learning and strategically allocate resources to navigate constraints. Kane et al. (2015) argue that effective strategy alignment, rather than technology alone, drives digital transformation success.

In addition, infrastructure and technical talent shortages remain critical factors. Access to broadband and ICT capabilities significantly enhance SME productivity (DeStefano et al., 2018). For firms lacking internal expertise, external collaborations – such as outsourcing and partnerships – can mitigate skill gaps (Vial, 2019). However, few studies explore systematic approaches to leveraging these strategies to reduce risks and enhance transformation efficiency.

2.3. Systemic Change in Digital Transformation

Digital transformation extends beyond technology adoption, requiring profound cultural and organizational changes. SMEs must dismantle traditional departmental silos, implement cross-functional teams, and adopt flatter management structures to fully leverage new technologies (Schallmo & Williams, 2018). At the same time, fostering a culture of continuous learning and adaptability is crucial for achieving transformation success (Fitzgerald et al., 2013).

Recent research highlights the interconnection between digitalization and business model innovation. SMEs can achieve sustainable transformation by integrating digitalization with business model innovation (Parida et al., 2019). Dynamic capabilities – such as cross-

functional collaboration and rapid resource reconfiguration – are identified as critical enablers of this process (Hanelt et al., 2021). Warner and Wäger (2019) further argue that cultivating a culture of continuous learning and strategic renewal enables SMEs to remain competitive in volatile markets. This aligns with Westerman et al. (2014), who emphasize that successful transformation requires embedding adaptability and innovation-oriented mindsets throughout the organization.

2.4. Policy Support and External Collaboration

Government policy is widely recognized as a critical enabler of SME digital transformation (OECD, 2019b). Public-private partnerships – such as Horizon 2020 in Europe and Smart Manufacturing programs in Asia – illustrate how financial subsidies, technical support, and targeted training programs can help SMEs overcome resource constraints. However, the effectiveness of these initiatives heavily depends on local conditions. In developing economies, unstable regulatory environments and insufficient infrastructure can significantly undermine policy outcomes (Feroz et al., 2021).

Strategic collaborations complement policy efforts by aligning digital transformation initiatives with long-term business objectives. Kane et al. (2015) highlight that public-private partnerships not only facilitate access to resources but also accelerate technology adoption. Kane et al. (2019) further emphasize that agile teams and external ecosystems enhance the dynamic capabilities required for SMEs to remain competitive in volatile markets. In China, initiatives such as the 'Made in China 2025' strategy and regional digital empowerment programs have significantly encouraged SMEs to invest in advanced digital tools, as shown by the Tencent Research Institute & State Administration for Market Regulation (2023).

Collaboration with technology providers, research institutions, and industry associations is equally important. Xu et al. (2018) note that Industry 4.0 initiatives increase production efficiency and foster SME integration into digital value chains. Hess et al. (2016) argue that effective digital strategies must combine internal planning with external partnerships to achieve sustainable transformation. Theoretical frameworks – such as Rogers' (2003) diffusion of innovations and Venkatesh and Bala's (2008) technology adoption models – provide valuable insights for policymakers, highlighting the roles of social influence, organizational readiness, and external support in shaping adoption patterns.

In summary, while government policies and external collaborations are vital, localized and context-specific approaches are essential for developing economies. Beyond financial subsidies, fostering innovation ecosystems, improving digital infrastructure and enabling cross-industry knowledge sharing are critical for overcoming resource and skill constraints, all of which are ultimately driving SMEs' digital transformation and long-term competitiveness.

2.5 Technology-Organization-Environment (TOE) Framework

The Technology-Organization-Environment (TOE) framework, introduced by Tornatzky et al. (1990), is widely recognized as a comprehensive model for analysing organizational technology adoption. It integrates three dimensions – technological, organizational, and environmental – to explain how firms evaluate, adopt, and implement new technologies. For SMEs, the technological context includes the perceived benefits, compatibility, and complexity of digital tools (Oliveira & Martins, 2011). The organizational context emphasizes internal resources, leadership capabilities, and employee skills (Li et al., 2018), while the environmental context captures competitive pressures, government regulations, and external support mechanisms (OECD, 2019b).

Recent research highlights TOE's applicability to SMEs because it considers both internal constraints (e.g., limited budgets, technical expertise) and external opportunities (e.g., policy incentives, industry collaborations) that affect digital transformation (Sagala & Őri, 2024; Nazaruddin & Utami, 2024). For Chinese SMEs, TOE offers a structured framework to assess how national initiatives such as "Made in China 2025" and local government programs influence technology adoption, highlighted by the Tencent Research Institute & State Administration for Market Regulation (2023).

2.6 Organizational Learning Theory (OLT)

Organizational Learning Theory (OLT), first proposed by Argyris and Schön (1978), emphasizes that organizations enhance performance by continuously converting knowledge into action and adapting to changing environments. OLT highlights the importance of a learning-oriented culture, where firms are not only responsive to external challenges but are also proactive in revising internal routines and assumptions (double-loop learning). In the SME context, OLT suggests that digital transformation success requires continuous skill development and cross-functional collaboration (Warner & Wäger, 2019). Leadership plays a key role in creating an environment that encourages experimentation and the sharing of digital knowledge (Vial, 2019).

Recent Chinese studies have found that SMEs with structured digital training programs, partnerships with universities or vocational colleges, and cross-departmental innovation initiatives achieve better transformation outcomes (China Academy of Information and Communications Technology & AII Alliance, 2023). Thus, OLT complements TOE by focusing on how internal learning mechanisms enhance the successful implementation of digital strategies.

2.7 Hypotheses development

Prior literature has identified several key factors influencing SMEs' digital transformation, including internal leadership, employee capabilities, and technological infrastructure. Drawing on both the Technology-Organization-Environment (TOE) framework and Organizational Learning Theory (OLT), this study develops the following hypotheses.

The TOE framework highlights organizational factors – including leadership – as key drivers of innovation. Organizational Learning Theory (Argyris & Schön, 1978) also emphasizes how leadership fosters internal knowledge sharing and capability building. In resource-constrained environments like emerging industrial regions, digital leadership becomes even more critical to initiate transformation. Prior studies confirm that SME leaders often face both skill gaps and strategic uncertainties (Westerman et al., 2014; Schallmo & Williams, 2018), which impact their ability to adopt new technologies. Based on this, we propose:

H1: Digital leadership from management significantly influences technology adoption in SMEs.

Previous studies underscore the importance of employee readiness and skill development in ensuring successful digital transformation (Vial, 2019; Romero & Mammadov, 2024). In SMEs, where technical expertise is often limited, continuous upskilling and cross-departmental collaboration can help build adaptive capacity. The TOE framework highlights organizational readiness as a critical internal determinant of digital adoption (Tornatzky et al., 1990). Organizational Learning Theory further supports that ongoing learning mechanisms and participatory knowledge sharing are essential to enabling transformation. Based on this, we propose:

H2: Employee skill development positively impacts the success of digital transformation in SMEs.

The relationship between technology adoption and firm performance has been widely documented (Verhoef et al., 2021). For SMEs, digital tools can increase efficiency and market reach, especially when supported by low-cost cloud platforms and mobile solutions. Even with constrained budgets, well-chosen technologies can yield notable productivity gains. In addition, while large firms may achieve economies of scale, SMEs often gain relative efficiency through focused, agile use of technology. The TOE framework considers the technological context – including perceived usefulness and ease of use – as central to performance outcomes. Based on this, we propose:

H3: Higher technology adoption rates are positively correlated with the financial performance of SMEs.

3. Research Methodology

This study employs a quantitative research design to explore the factors influencing the success of digital transformation in SMEs operating in emerging industrial regions of China. Grounded in the Technology-Organization-Environment (TOE) framework (Tornatzky et al., 1990) and Organizational Learning Theory (Argyris & Schön, 1978), the research investigates the roles of management support, employee skill development, and technology adoption rates in driving digital transformation outcomes. To test the proposed hypotheses, data were collected through a structured questionnaire and analysed using SPSS 27.0.

3.1 Questionnaire Design and Data Collection

The questionnaire was developed based on validated scales from prior studies on SME digital transformation (e.g., Vial, 2019; Li et al., 2018) and the TOE framework. To ensure the questionnaire's quality, we conducted a pilot test with 30 SMEs from various sectors to evaluate the clarity of items and their relevance to the Chinese SME context. The pilot results led to minor wording adjustments and improved logical flow.

The validity and reliability of the final survey were confirmed via Cronbach's alpha (all constructs > 0.7), KMO (> 0.65), and Bartlett's test ($p < 0.001$), verifying internal consistency and construct validity (see Section 4 for further details). The survey comprised four primary sections: Demographic and organizational information (included details such as industry type, company size, and years of operation); Management support and leadership (measured by four items assessing strategic decision-making and digital leadership); Employee skills and training (five items evaluating workforce readiness and training effectiveness); and Technology adoption and digital transformation outcomes (twelve items assessing the extent of technology use, operational efficiency, and transformation success).

Most survey items utilized a five-point Likert scale ranging from "strongly disagree" to "strongly agree" to ensure consistency in responses. The target group comprised professionals directly involved in digital transformation efforts, including IT managers, project managers, department heads, and general managers. The surveyed SMEs were primarily located in emerging industrial regions of China, including Anhui, Henan, Hubei, Jiangxi, Sichuan, and Chongqing. In terms of industry distribution, 31.0% of respondents were from the retail sector, 26.7% from IT services, 23.1% from the general service sector, and 19.1% from manufacturing. With respect to firm size, the most common category was 51–100 employees (33.0%), followed by 11–50 employees and 101–250 employees. These characteristics align with the official classification of SMEs in China. The survey was conducted online via Wenjuanxing, a widely used online survey platform in China, and was distributed through targeted WeChat group invitations and professional networks in industry groups, Liepin communities. To ensure that respondents were relevant to the study, the questionnaire began with a background screening section that captured organizational details (e.g., location, sector, size, and age) and respondent characteristics (e.g., role, tenure, education level, and familiarity with digital transformation tools and strategy). This ensured that the final sample included only participants with informed perspectives on digital transformation in SMEs. A total of 500 questionnaires were distributed, and 303 valid responses were collected, which gives a 60.6% response rate.

3.2 Data Analysis Methods

SPSS 27.0 was employed to conduct a series of statistical analyses, which ensures a rigorous examination of the research hypotheses and objectives. Descriptive Statistical Analysis was employed to summarized demographic and organizational characteristics of the surveyed SMEs to provide a contextual overview. The following table (Table 2) gives an overview of the data analysis methods and variables for the hypotheses of this study.

Table 2. Overview of the hypotheses to be tested with the corresponding variables and analytical methods. *Source: Authors' own*

Hypothesis	Independent Variable(s)	Dependent Variable	Analytical Method
H1	Digital leadership	Technology adoption	Multiple regression
H2	Employee skills	Digital transformation success	Multiple regression
H3	Technology adoption	Financial performance	Multiple regression

With Pearson Correlation Analysis, we Investigated linear relationships between key variables, such as management digital leadership, employee skill development, technology adoption rates, and financial performance. Multiple Regression Analysis tested the proposed hypotheses by evaluating the relative influence of independent variables (e.g., management support, employee skills) on dependent variables (e.g., digital transformation outcomes, financial performance). Factor Analysis assessed construct validity using KMO and Bartlett's tests, for identifying meaningful factors through eigenvalues and cumulative variance percentages. These statistical tools enabled the study to validate its findings and ensure their robustness and credibility, thereby the study provides insights into the key drivers of digital transformation in SMEs.

Although the regression models show relatively low R^2 values (e.g., 8.2% for technology adoption's impact on financial performance), this is consistent with social science studies involving complex constructs and unobserved factors (Verhoef et al., 2021). The findings remain statistically significant and provide valuable insights into the role of leadership, skills, and technology. We also attempted to exclude variables with low communalities in factor analysis, but the improvement was marginal, which suggests that digital transformation outcomes are inherently influenced by diverse and unobserved variables such as market volatility or policy changes.

4. Results

4.1 Descriptive Statistical Analysis

The survey results provide an overview of the participants' company backgrounds, roles, and familiarity with digital transformation strategies, as shown in table 3.

Table 3. Descriptive Statistics of Company and Participant Characteristics. *Source: Authors' own*

Demographic	Category	Frequency	Percent (%)
Industry	Manufacturing	58	19.1
	Services	70	23.1
	Retail	94	31.0
	Information Technology	81	26.7
Company Size	1-10 employees	17	5.6
	11-50 employees	84	27.7
	51-100 employees	100	33.0
	101-250 employees	62	20.5
	More than 250 employees	40	13.2
Years in Operation	Less than 1 year	12	4.0
	1-5 years	93	30.7
	6-10 years	129	42.6
	Over 10 years	69	22.8
Role in Company	CEO / general manager / owner	15	5.0
	Department head (e.g., IT, Operations, Marketing)	69	22.8

Demographic	Category	Frequency	Percent (%)
	IT manager / digital transformation officer	118	38.9
	Project manager in digital transformation projects	99	32.7
	Other (please specify)	2	0.7
Age	25-34 years	107	35.3
	35-44 years	134	44.2
	45-55 years	62	20.5
Education Level	Associate's degree	9	3.0
	Bachelor's degree	175	57.8
	Master's degree or above	119	39.3
Familiarity with Digital Strategies	Familiar	106	35.0
	Very familiar	197	65.0

Participants primarily represent four industries: manufacturing (19.1%), services (23.1%), retail (31.0%), and information technology (26.7%). Most companies fall within the 51-100 employee range (33.0%), and the majority have been in operation for 6-10 years (42.6%). IT managers and digital transformation officers (38.9%) as well as project managers (32.7%) are the primary leaders of digital transformation efforts, while CEOs, general managers, and owners constitute only 5.0%.

Participants are predominantly aged 35-44 (44.2%) and 25-34 (35.3%), with 57.8% holding a bachelor's degree and 39.3% possessing a master's degree or higher. Additionally, 65.0% of respondents report being "very familiar" with their company's digital transformation strategies and tools, which underscores their direct involvement in these initiatives. The following table indicates the primary motivations, challenges, barriers and strategies for adopting digital tools (Table 4).

Table 4. Factors affecting adoption of digital tools in SMEs. *Source: Authors' own*

Factors	Frequency (N)	Percentage (%)	Percentage of cases (%)
Motivations			
To improve operational efficiency	273	30.5%	90.1%
To increase market competitiveness	221	24.7%	72.9%
To reduce costs	168	18.8%	55.4%
To enhance customer experience	125	14.0%	41.3%
To comply with industry standards	99	11.1%	32.7%
Other	8	0.9%	2.6%
Challenges			
Data security concerns	281	31.8%	92.7%
Incompatibility with existing systems	249	28.2%	82.2%
High implementation costs	131	14.8%	43.2%
Employee resistance to change	108	12.2%	35.6%
Lack of technical expertise	103	11.7%	34.0%
Other	11	1.2%	3.6%
Barriers			
Regulatory barriers	263	25.5%	86.8%
Lack of management support	193	18.7%	63.7%
Insufficient funding	178	17.2%	58.7%
Lack of technical support	125	12.1%	41.3%
Lack of employee skills	113	10.9%	37.3%
Market uncertainty	87	8.4%	28.7%

Limited management knowledge of digital tools	68	6.6%	22.4%
Other (please specify)	6	0.6%	2.0%
Strategies			
External financing	268	30.0%	88.4%
Government policy support	181	20.2%	59.7%
Employee skill training	151	16.9%	49.8%
External technical collaboration	149	16.7%	49.2%
Partnerships with Chinese tech firms (e.g., Alibaba, Tencent)	139	15.5%	45.9%
Other (please specify)	6	0.7%	2.0%

a. Dichotomy group tabulated at value 1

Improving operational efficiency (30.5%), increasing market competitiveness (24.7%), and reducing costs (18.8%) emerge as the top three motivations. Among these, enhancing operational efficiency was emphasized by 273 companies, which reflects a strong focus on optimizing internal management and workflows. Additionally, 221 companies cited market competitiveness, which highlights the importance of digital transformation for maintaining a competitive edge.

Reducing costs was another significant motivation, with 168 companies (18.8%) aiming to achieve economic benefits through cost control. Improving customer experience (14.0%) and compliance with industry standards (11.1%) were also noted, albeit with smaller proportions. Only 0.9% of companies selected "other" reasons, which indicates that most motivations are well-defined and shared across the surveyed organizations.

Companies face diverse challenges in implementing digital tools, with data security and system incompatibility being the most prominent challenges. Data security issues were reported by 31.8% of companies (281 companies), which emphasizes the critical importance of protecting sensitive information during digital transformation. System incompatibility was identified by 28.2% of companies (249 companies), which reflects difficulties in integrating new tools with legacy systems.

Other notable challenges include high implementation costs (14.8%), employee resistance to change (12.2%), and a lack of technical expertise (11.7%), which were reported by 131, 108, and 103 companies, respectively. Only 1.2% of companies selected "other" challenges, which suggests that the obstacles faced by organizations are generally well-defined and shared.

The survey results also reveal key obstacles to advancing digital transformation, with regulatory barriers (25.5%), lack of management support (18.7%), and funding shortages (17.2%) being the most critical. Regulatory barriers were identified by 263 companies, which highlights the influence of policy environments on the digitalization process. Insufficient management support was reported by 193 companies, and this underscores the critical role of leadership in driving transformation. Funding shortages, cited by 178 companies, reflect difficulties in resource allocation and financial planning. Other obstacles include insufficient technical support (12.1%), lack of employee skills (10.9%), limited management understanding of digital tools (6.6%), and market uncertainty (8.4%). Only 0.6% of companies selected "other" reasons, which suggests that these challenges are largely consistent across organizations.

To overcome these obstacles, companies adopt a range of strategies, with external financing (30.0%) and government policy support (20.2%) emerging as the most prominent ones. External financing was identified by 268 companies as the top solution, which reflects the urgent need for funding to advance digital initiatives.

Government policy support, cited by 181 companies, highlights the importance of incentives and supportive policies in facilitating digital transformation. Additional strategies include employee skills training (16.9%), external technical collaboration (16.7%), and partnerships with domestic tech giants such as Alibaba and Tencent (15.5%). These approaches emphasize the role of internal capacity building, external expertise, and industry collaboration in addressing digital transformation challenges.

4.2 Reliability and validity analysis

Cronbach's Alpha coefficients were used to evaluate the internal consistency and reliability of the survey scales. Technology Adoption and Use (12 items): α = 0.883, which indicates excellent internal consistency. Employee Skills and Training (5 items): α = 0.702, which reflects acceptable reliability. Management Support and Leadership (4 items): α = 0.710, which also indicates acceptable reliability. Digital Transformation Outcomes (20 items): α = 0.879, which demonstrates very high reliability. These results confirm strong internal consistency across variables, with particularly high reliability for scales with more items.

Factor analysis results confirm the validity of the constructs, which are supported by high KMO values. Technology Adoption and Use: KMO = 0.915; cumulative variance explained = 62.184%. Employee Skills and Training: KMO = 0.682; single factor explains 33.560% of variance. Management Support and Leadership: KMO = 0.651; single factor explains 40.620% of variance. Digital Transformation Outcomes: KMO = 0.901; cumulative variance explained = 60.337%.

These results demonstrate strong data suitability and confirm that the measured constructs have robust explanatory power. More precisely, the findings indicate that digital transformation outcomes are influenced by multiple interrelated factors, with each contributing a relatively balanced share of explanatory power, which underscores the multifaceted nature of the constructs. The full results of the factor analysis can be found in appendix A.

Factor loadings further validate the strength of the constructs. The full results of the factor loadings can be found in appendix B. Technology Adoption and Use: Loadings range from 0.610 to 0.759, which demonstrates a strong relationship between the variables and the construct, with consistently high loadings supporting validity. Employee Skills and Training: Loadings range from 0.575 to 0.688, which indicates a significant contribution to the construct, though slightly lower compared to Technology Adoption and Use. Management Support and Leadership: Loadings range from 0.558 to 0.696, which reflects moderate but meaningful associations with the construct. Digital Transformation Outcomes: Loadings range from 0.648 to 0.948, with variables D16 to D20 exhibiting particularly strong associations (all above 0.8), which underscores their critical role in this construct. These results confirm that the constructs are well-defined and are effectively measured by their respective indicators, which provides strong empirical support for their validity.

4.3 Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships between key variables:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

Here, r is the Pearson correlation coefficient, X_i and Y_i are the observed sample values of two variables, $\bar{X}$ and $\bar{Y}$ are the sample means of the two variables, and nnn is the number of observations. The formula calculates the covariance between the two variables and standardizes it. Standardization is achieved by division using the product of the standard deviations of the two variables, which ensures that the resulting correlation coefficient is not affected by the units of the variables. The analysis reveals the following significant relationships between the key variables (as shown in table 5):

Table 5. Pearson Correlation Matrix of Key Variables. *Source: Authors' own*

Variable	Technology Adoption	Employee Skill Development	Digital Leadership	Digital Transformation	Financial Performance
Technology Adoption	1				
Employee Skill Development	0.416**	1			
Digital Leadership	0.377**	0.461**	1		
Digital Transformation	0.361**	0.549**	0.475**	1	
Financial Performance	0.286**	0.304**	0.314**	0.283**	1

** Correlation is significant at the 0.01 level (2-tailed).

Management's digital leadership is positively correlated with technology adoption and cultural transformation ($r = 0.377$, $p < 0.01$). Employee skill development and cross-departmental collaboration are strongly correlated with digital transformation success ($r = 0.549$, $p < 0.01$). Higher technology adoption rates are positively correlated with SMEs' financial performance ($r = 0.286$, $p < 0.01$). These preliminary results validate the hypothesized relationships and highlight the critical roles of leadership, employee skills, and technology adoption in achieving successful digital transformation.

4.3 Regression Analysis

The regression results examine the impact of the management's digital leadership on technology adoption and cultural transformation within organizations. The results are shown in the following table (Table 6):

Table 6. Regression results for key variables. *Source: Authors' own*

Dependant variable	Model	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig.
		(B)	Std. Error	(Beta)		
Technology Adoption	(Constant)	2.390	0.228		10.462	<0.001
	Digital Leadership	0.433	0.061	0.377	7.053	<0.001
	R^2			0.142		
	Adjusted R^2			0.139		
	F-Value			49.743***		
Digital Transformation	(Constant)	1.651	0.184		8.996	<0.001
	Employee Skill Development	0.556	0.049	0.549	11.394	<0.001
	R^2			0.301		
	Adjusted R^2			0.299		
	F-Value			129.815***		
Financial Performance of SMEs	(Constant)	2.302	0.311		7.397	<0.001
	Technology adoption rate	0.398	0.077	0.286	5.176	<0.001
	R^2			0.082		
	Adjusted R^2			0.079		
	F-Value			26.796***		

* $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$

Based on the regression analysis and in line with the proposed model, all three proposed hypotheses are supported. Digital leadership was found to significantly influence technology adoption and cultural transformation (H1 supported, $\beta = 0.377$, $p < 0.001$). Employee skill development and cross-departmental collaboration had a strong positive impact on digital transformation outcomes (H2 supported, $\beta = 0.549$, $p < 0.001$). Finally, technology adoption was positively correlated with financial performance, although the effect size was relatively modest (H3 supported, $\beta = 0.286$, $p < 0.001$). These results confirm the theoretical pathways outlined in the TOE and Organizational Learning frameworks.

5. Discussion

All three hypotheses (H1–H3) are supported, but their explanatory power varies. H2 (employee skill development and collaboration) demonstrates the strongest influence on digital transformation success (R^2 = 0.301), which underscores the pivotal role of workforce adaptability and cross-departmental collaboration. In contrast, H3 (technology adoption and financial performance) shows a relatively modest relationship (R^2 = 0.082), which indicates that technology adoption alone does not guarantee performance improvements unless it is strategically aligned with broader business goals and is integrated with organizational processes. These results are consistent with Verhoef et al. (2021), who argue that technology must be embedded within strategic models to yield measurable benefits.

The low explained variance in factor analysis partly reflects the heterogeneous nature of SMEs across industries and regions. We evaluated our results by excluding variables with low communalities but found little improvement. This suggests that unobserved factors—such as sector-specific dynamics, supply chain integration, and policy interventions—also affect outcomes. Future research can address this limitation by expanding the variable set, by conducting industry-specific analyses, or by adopting longitudinal approaches to capture the evolving nature of digital transformation.

Management support remains a pivotal factor in enabling technology adoption and cultural change. Digital leadership, characterized by strategic vision and effective resource allocation, not only facilitates the acceptance of new technologies but also fosters employee collaboration and innovation. These findings align with Schallmo and Williams (2018), who highlight leadership as a cornerstone of successful digital transformation.

Employee skill development emerges as a key driver of success, particularly for resource-constrained SMEs. Workforce adaptability and cross-functional collaboration are critical for implementing new tools effectively. This supports Vial (2019), who highlights that digital initiatives succeed when employees are prepared to integrate technological advancements into daily operations. Investing in targeted training and continuous upskilling ensures SMEs can fully leverage digital technologies.

While a positive correlation exists between technology adoption and financial performance, the modest R^2 values suggest that technology investments must be strategically aligned to create tangible business value. This reinforces the idea that digital transformation is not simply a technological upgrade, but a strategic and organizational initiative.

6. Implications

Based upon the findings, SME leaders should establish “digital champion” programs to empower mid-level managers in driving small-scale innovation projects. Moreover, partnerships with local vocational institutes or technology training providers should be leveraged to create modular, cost-effective upskilling pathways for employees. Policymakers should improve digital infrastructure and provide targeted support mechanisms, such as digital adoption vouchers, low-interest financing, advisory services, and government-backed training programs. These initiatives address resource and skill gaps while enabling SMEs to accelerate transformation efforts.

To operationalize these recommendations, SMEs can implement pilot digital projects led by trained champions and should gradually scale up based on measurable outcomes. In the meantime, policymakers can foster innovation ecosystems that promote cross-industry digital knowledge exchange, thereby creating an environment conducive to sustained digital adoption and competitiveness.

7. Conclusions and future research directions

This study investigates the critical success factors for digital transformation in small and medium-sized enterprises (SMEs) operating in China’s emerging industrial regions, and focuses on management support, employee skill development, and technology adoption rates.

The findings validate the independent effects of these factors while emphasizing their synergistic relationships and combined influence on financial performance.

Future research should adopt longitudinal designs to track how management support, employee skills, and technology adoption affect outcomes over time. Expanding the study to SMEs from diverse economic and cultural contexts would also provide comparative insights. As this study focuses on China's emerging industrial regions, its findings may not fully generalize to other settings. The examination of how varying regulatory environments, cultural attitudes, and resource availability shape transformation strategies could uncover new insights. Similarly, industry-specific analyses would reveal sectoral differences, as manufacturing enterprises may prioritize supply chain optimization while retail businesses emphasize customer experience. Additionally, future research could explore the role of external partnerships and resource integration in overcoming technical and financial barriers. Collaborations with technology providers, government agencies, or industry associations are likely to play a critical role in enabling resource-constrained SMEs to achieve their digital transformation goals. Finally, as emerging technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) continue to evolve, future studies should investigate the integration of such technologies into transformation processes. Understanding how these technologies reshape organizational cultures and management practices will be crucial for addressing the challenges of future business environments.

By addressing these areas, future research can build on the findings of this study, contributing to a more comprehensive understanding of the mechanisms and outcomes of digital transformation in SMEs. While future research can further advance this agenda, the current study already offers empirical support for several theoretical insights previously proposed in the literature. These findings align with prior literature emphasizing the role of digital leadership (Schallmo & Williams, 2018) and employee adaptability (Vial, 2019) in facilitating digital transformation. The results of this study also support the Organizational Learning Theory perspective (Argyris & Schön, 1978), which indicates that successful transformation depends on continuous learning, cultural alignment, and capability development. Moreover, the modest explanatory power of technology adoption on financial performance echoes the conclusions of Verhoef et al. (2021), who argue that technological tools must be strategically integrated with broader business models to yield tangible outcomes.

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Appendices

Appendix A. Results of Factor Analysis for Survey Variables. *Source: Authors' own*

Variable	KMO	Factor	Eigenvalue	Variance Explained (%)	Cumulative Percentage (%)	Bartlett's χ^2 (df)	p-value
Technology Adoption and Use	0.915	1	5.353	38.333	38.333	1686.144 (66)	< 0.001
		2	2.109	23.851	62.184		
Employee Skills and Training	0.682	1	1.678	33.56	33.56	70.246 (10)	< 0.001
Management Support and Leadership	0.651	1	1.625	40.62	40.62	67.902 (6)	< 0.001
Digital Transformation Outcomes	0.901	1	6.259	24.203	24.203	2434.727 (190)	< 0.001
		2	2.612	15.729	39.932		
		3	2.157	15.024	54.955		
		4	1.039	5.381	60.337		

Appendix B. Factor Loadings for Survey Variables. *Source: Authors' own*

Technology Adoption and Use	Factor Loading	Employee Skills and Training	Factor Loading	Management Support and Leadership	Factor Loading	Digital Transformation Outcomes	Factor Loading
A1	0.729	B1	0.616	C1	0.558	D1	0.684
A2	0.703	B2	0.585	C2	0.661	D2	0.689
A3	0.712	B3	0.622	C3	0.626	D3	0.664
A4	0.759	B4	0.575	C4	0.696	D4	0.656
A5	0.746	B5	0.688			D5	0.693
A6	0.738					D6	0.648
A7	0.703					D7	0.682
A8	0.729					D8	0.709
A9	0.682					D9	0.688
A10	0.610					D10	0.696
A11	0.596					D11	0.791
A12	0.679					D12	0.773
						D13	0.776
						D14	0.765
						D15	0.733
						D16	0.818
						D17	0.846
						D18	0.825
						D19	0.824
						D20	0.948